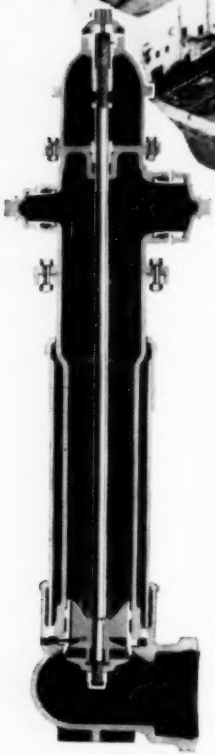
APRIL 1949

Journal

VOL. 41 • NO. 4

AMERICAN WATER WORKS ASSOCIATION

Philadelphia
Water Works—
Early Blue Plate Special



MERCED, CALIF.

"One of America's Safest Cities"
THE MATHEWS FIREMEN SAY

THEY FIGURE IT OUT THIS WAY: Merced, California is protected by Mathews Modernized Hydrants, and wherever these hydrants are, *there* is safety plus.

Some Mathews in service today started their long, trouble-free life before there was a seedless orange in California. This *proved* dependability, plus modern features, makes today's version a standard by which all hydrants are judged. The thread is proof against rusting and deposits of silt. The revolving nut is protected against rain and dust. The main valve is true compression-type; the drain valve drains perfectly dry. All working parts are contained in a removable barrel—easily and quickly replaced.

Send for descriptive literature. See why you owe it to your community to provide this safety plus.

OTHER MATHEWS FEATURES: Head can be rotated 360° • Replaceable head—nozzle outlets easily changed • Nozzle level raised or lowered—no excavating • Stuffing box cast integral with nozzle section • Only one part to lubricate—operating thread • A modern barrel makes even the oldest Mathews new

MATHEWS HYDRANTS

***Made by* R. D. WOOD COMPANY**

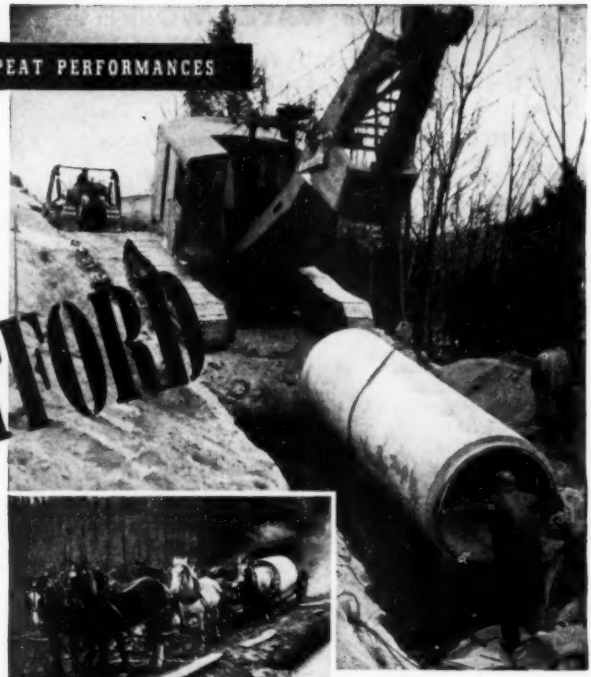
Public Ledger Building, Independence Square, Philadelphia 5, Pa.

Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves

LOCK JOINT REPEAT PERFORMANCES

HARTFORD

9 JOBS SINCE 1918



1940—Top photo: Modern installation of 48" concrete cylinder pipe.

For almost 30 years the increasing demand upon the water supply system of Hartford has been met with Lock Joint pressure pipe lines. Since 1918 nine separate contracts for supplementing the City's existing water supply system have been awarded to Lock Joint Pipe Company. By specifying Lock Joint Reinforced Concrete Pressure Pipe, Hartford, the insurance capital, has assured itself of water supply lines of unfailing service whose estimated life expectancy is better than 100 years!

Repeat orders from Hartford and many other progressive American cities are convincing evidence of the permanent high quality and complete reliability of Lock Joint Reinforced Concrete Pressure Pipe.

SCOPE OF SERVICES—*Lock Joint Pipe Company specializes in the manufacture and installation of Reinforced Concrete Pressure Pipe for Water Supply and Distribution Mains in a wide range of diameters as well as Concrete Pipe of all types for Sanitary Sewers, Storm Drains, Culverts and Subaqueous Lines.*

For future projects, large or small, specify Lock Joint Pipe.

A Hazen-Williams Hydraulic Slide Rule will gladly be sent upon request with our compliments.

1918—Lower photo: Delivery of 48" pipe by six horse team.

★

LOCK JOINT PIPE COMPANY

Established 1905

P. O. Box 269, East Orange, N. J.

Pressure Pipe Plant: Wharton, N. J.

Sewer Plant: Kenilworth, N. J.

BRANCH OFFICES: Denver, Colo. Chicago, Ill. • Kansas City, Mo. Rock Island, Ill. • Joplin, Mo. • Valley Park, Mo. • Cleveland, Ohio • Hartford, Conn. • Navarre, Ohio

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Reinforced Concrete
PRESSURE PIPE

AMERICAN WATER WORKS ASSOCIATION

500 Fifth Avenue, New York 18, N.Y.

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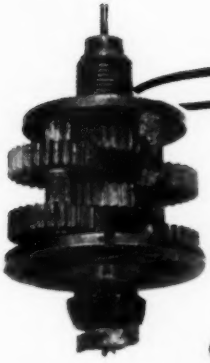
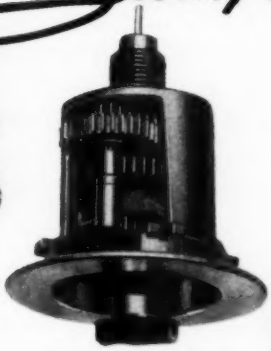
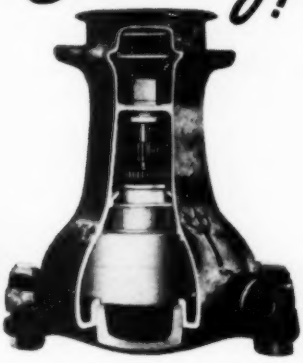
Seeing is Believing!



Unprotected Gear Train, removed from 1898 Trident Meter



Modern Oil-Enclosed Gear Train fits into old Trident Meter



See how easily you can modernize old Tridents

YES you can modernize old Tridents so quickly, simply, inexpensively! The shopman just picks up a modern Trident Oil-enclosed Gear Train and slips it into the old Trident meter casing. It replaces the open gear train on the old-type oil-enclosed train (5/8", 3/4" and 1" meters use identical gear trains.)

And interchangeability is not limited to units. Modern parts, gears, etc. can be used to repair old units. Buy Trident Meters for TRUE standardization, which you can only get through complete interchangeability.

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NEPTUNE METERS, LTD., Long Branch, Ont., Canada

203

Trident Interchangeability means **TRUE** standardization

III

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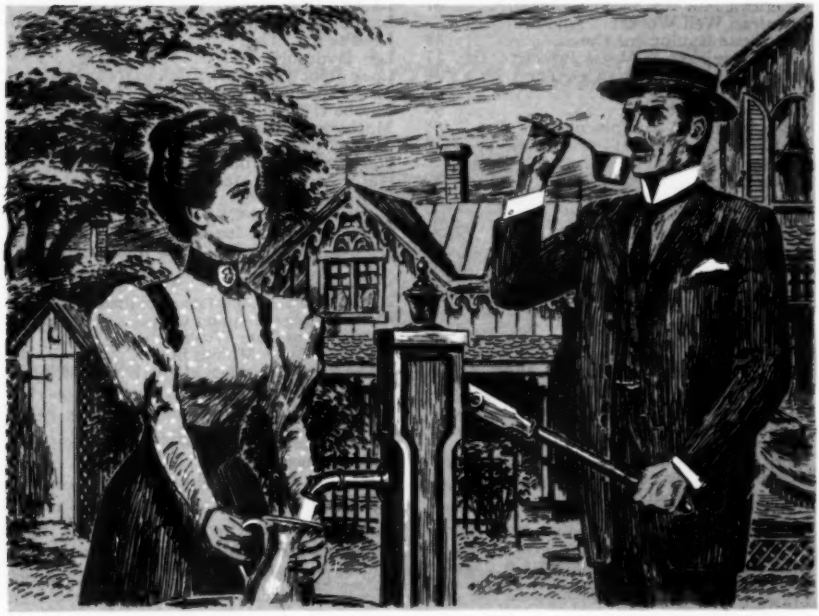
"Tastes kind of funny lately, Ma?"



DURING the past half-century, sanitary engineering has made great strides in combatting diseases caused by pollution of water sources. The year 1899, when our Company was established, also marked the development of sewage treatment in America. Today, more than 6,000 sewage treatment plants are in operation serving over half of our urban population.

The growth of water supply and gas service during this period has been equally remarkable. Today, 12,000 public water supply systems serve 85 million people. More than 20 million homes are furnished with gas for cooking and heating.

It has been our privilege to share in the progress of these public services by providing cast iron pressure pipe, for water, gas and sewer mains, and for sewage treatment and water purification plants. Better pipe today, naturally, than 50 years ago—stronger, tougher, more uniform in quality. An old-time pipe founder would be amazed by the improved casting methods, production standards and quality controls in operation at our several foundries.

To those responsible for the great progress in water supply, gas and sanitation service and their contribution to better health and living over the past fifty years America pays tribute.

U.S. CAST IRON PIPE

1899-1949

U. S. Pipe & Foundry Co.

Makers for 50 years of cast iron pipe for water, gas and sewerage service

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LIST OF ADVERTISERS

American Brass Co., The ix
American Cast Iron Pipe Co. ..... —
American Cyanamid Co., Industrial Chemicals Div. 66
American Pipe & Construction Co. 57
American Well Works ..... —
Anthracite Equipment Corp. 44
Armco Drainage & Metal Products, Inc. 17
Atlas Mineral Products Co., The 38
Badger Meter Mfg. Co. ..... —
Barrett Div., The 39
Belco Industrial Equipment Div., Inc. .. 63
Blakiston Co., The 28
Buffalo Meter Co. 77
Builders-Providence, Inc. 83
Calgon, Inc. ..... —
Carson-Cadillac Co 78
Cast Iron Pipe Research Assn., The 52–53
Central Foundry Co., The 38
Centriline Corp. 67
Chain Belt Co. 43
Chicago Bridge & Iron Co. 13
Clow, James B., & Sons 45
Dearborn Chemical Co. ..... —
De Laval Steam Turbine Co. 3
Difco Laboratories ..... —
Dorr Co., The ..... Cover 3
Dowell Incorporated ..... —
Dresser Mfg. Div. 33
Economy Pumps, Inc. ..... —
Eddy Valve Co. 45
Electric Fish Screen Co. 30
Electro Rust-Proofing Corp. 76
Ellis & Ford Mfg. Co. ..... —
Everson Mfg. Corp. 78
Fairbanks, Morse & Co. 35
Flexible Sewer-Rod Equipment Co ..... —
Ford Meter Box Co., The 41
Fraser Utility Supply Co. ..... —
General Chemical Div., Allied Chemical & Dye Corp. ..... —
Glauber Brass Mfg. Co., The ..... —
Greenberg's, M., Sons ..... —
Michael Hayman & Co., Inc. 32
Havs Mfg. Co. 85
Hellige, Inc. 64
Hersey Mfg. Co. 61
Hydraulic Development Corp. 21
Industrial Chemical Sales Division, West Virginia Pulp & Paper Co. x
Inertol Co., Inc. 40
Infilco, Inc. 75
Iowa Valve Co. 65
Johns-Manville Corp. vii
Jones, J. W., Co. 20
James Jones Co 49
Keasbey & Mattison Co. 87
Kennedy Valve Mfg. Co., The ..... —
Klett Mfg. Co. 46
Koppers Co., Inc. 79
Kupferle, John C., Foundry Co. 32
LaMotte Chemical Products Co. ..... —
Layne & Bowler, Inc. 47
Leadite Co., The ..... Cover 4
Lee Hydraulic Co ..... —
Lock Joint Pipe Co. i
M & H Valve & Fittings Co. 15
Mabbs Hydraulic Packing Co. ..... —
Mathieson Chemical Corp. ..... —
Mueller Co. 69
National Cast Iron Pipe ..... —
National Water Main Cleaning Co. 23
Neptune Meter Co. iii
Northern Gravel Co. 68
Northrop & Co., Inc. 70
Omega Machine Co. (Div., Builders Iron Fdry.) 55
Peerless Pump Div. ..... —
Permutit Co. 9
Phelps Dodge Refining Corp. ..... —
Philadelphia Gear Works, Inc. 22
Pittsburgh-Des Moines Steel Co. 71
Pittsburgh Equitable Meter Div. (Rockwell Mfg. Co.) 88
Pollard, Jos. G., Co., Inc. 56
Portland Cement Assn. 5
Preload Companies, The ..... —
Proportioneers, Inc. 31
Reilly Tar & Chemical Co. ..... —
Rensselaer Valve Co. 81
Roberts Filter Mfg. Co ..... —
Ross Valve Mfg. Co. ..... —
Simplex Valve & Meter Co. ..... —
Smith, A. P., Mfg. Co., The 7
Solvay Sales Div., Allied Chemical & Dye Corp. ..... —
Sparling, R. W. 37
Standard Pipeprotection, Inc. 73
Stuart Corp. 14
Syntron Co. ..... —
Tagco, Inc. 44
Tate Pipe Lines, Inc. ..... —
Tennessee Corp. ..... —
U. S. Pipe & Foundry Co. v
Virginia Smelting Co. ..... —
Walker Process Equipment, Inc. 51
Wallace & Tiernan Co., Inc. xii
Warren Foundry & Pipe Co. 11
Well Machinery & Supply Co. 29
Welsbach Corp., Ozone Processes Div. .. 59
Wood, R. D., Co. ..... Cover 2
Worthington-Gamon Meter Co. 19
Zeolite Chemical Co. 72

Directory of Professional Services—pp. 24-27

Albright & Friel, Inc.
Alvord, Burdick & Howson
Behrman, A. S.
Black & Veatch
Clinton L. Bogert Assoc.
Bowe, Albertson & Assoc.
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Engineering Facts about
Johns-Manville TRANSITE PRESSURE PIPE
Making Large Service Connections

READY adaptability to standard waterworks practice is an advantage of Transite* Pressure Pipe which is of special importance when making large service connections. Thousands of such connections are in service today, installed in Transite supply and distribution lines with standard equipment and tools under a variety of installation and working conditions.

A 24-inch Transite main being tapped under full working pressure for a 20-inch branch connection.

For tapping the line under pressure, conventional tapping sleeves, tapping valves and drilling machines are generally used. The sleeves are first leaded and caulked in the usual manner. Sleeves to fit all sizes of Transite Pressure Pipe are available from several manufacturers. Tough and strong, the pipe wall is, nevertheless, readily drilled; Transite's unusual machinability assures a clean cut.

In cases where the line can be temporarily removed from service, a commonly used method of providing large connections is to insert into the line a fitting† such as a tee having the required outlet size. To do this, a section of pipe is first removed from the line. The Simplex Coupling permits quick removal and with a minimum of trench excavation. Two stubs of pipe are then cut from this section and inserted into the bells of the fitting to form an assembly of equivalent length to that of the section removed. No problem arises in joining stub ends and fitting, since lead or compound joints are readily made with Transite. Replacement of the assembly in the line is easily and quickly made with the standard Simplex Couplings.

A method sometimes used for making connections when the line is under pressure is the use of service clamps of the type equipped with double straps. These may be used for making service connections larger than those recommended for corporation stops inserted directly into the wall of the pipe or where multiple corporation stops are not used. After the service clamp and corporation stop are attached, the pipe wall is drilled with conventional drilling tools. Service clamps are not used for outlets exceeding one-quarter the diameter of the street main, nor larger than 4".

A previous advertisement in this series discussed tapping Transite Pressure Pipe for small service connections. A reprint is available on request. Address Johns-Manville, Box 290, New York 16, N. Y.

†The run of the fitting should have bell ends. Enlarged bells are used for class 150 pipe over 8" diameter.

Conventional methods are used for making large service connections in Transite lines. Here are shown a tapping sleeve and valve being installed on a 12" line under pressure for a 4" outlet.

* Transite is a registered Johns-Manville Trade Mark

JOHNS-MANVILLE JM PRODUCTS

COMING MEETINGS

April

20–22—Indiana Section at Lincoln Hotel, Indianapolis. Secretary: C. H. Bechert, Director, Div. of Water Resources, Indiana Dept. of Conservation, 445 N. Pennsylvania Ave., Indianapolis 4, Ind.

21–22—Kansas Section at Bisonte Hotel, Hutchinson, Kan. Secretary: Major C. Hagar, Supt., Water Dept., Lawrence, Kan.

21–22—Nebraska Section at Cornhusker Hotel, Lincoln, Neb. Secretary: John W. Cramer, Partner, Fulton & Cramer, 922 Trust Bldg., Lincoln 8, Neb.

24–27—Canadian Section at Chateau Frontenac, Quebec City, Que. Secretary: Dr. A. E. Berry, Director, Ontario Dept. of Health, Parliament Bldgs., Toronto 2, Ont.

28–29—New York Section at Mark Twain Hotel, Elmira, N.Y. Secretary: R. K. Blanchard, Vice-President, Neptune Meter Co., 50 W. 50th St., New York.

29—California Section regional spring meeting at Bakersfield, Calif. Secretary: H. C. Medbery, Engr. of Water Purification, San Francisco Water Dept., Millbrae, Calif.

May

12–14—Pacific Northwest Section at Bellingham Hotel, Bellingham, Wash. Secretary, Fred Merryfield, 204 Industrial Bldg., 17th & May Sts., Corvallis, Ore.

A.W.W.A. 1949 ANNUAL CONFERENCE

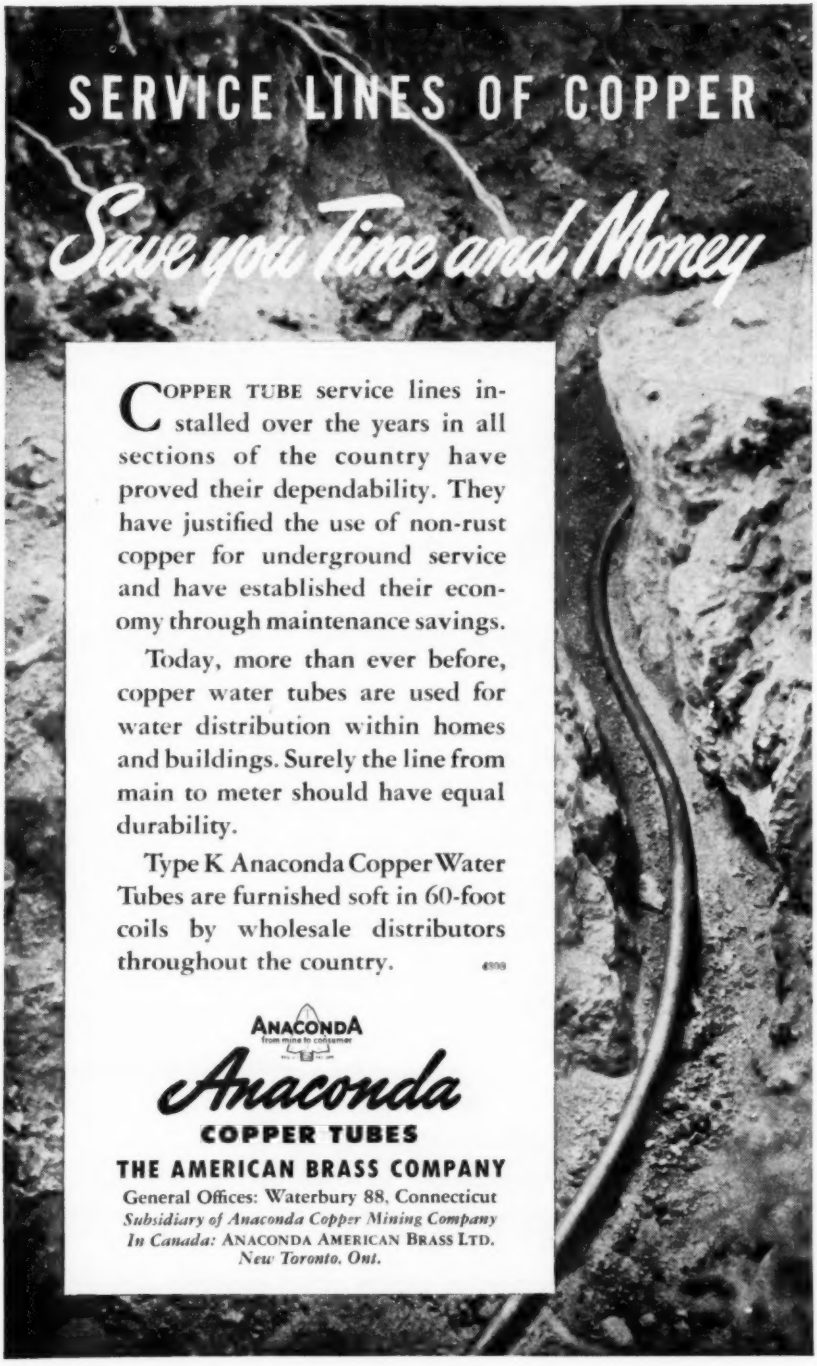
Stevens Hotel, Chicago **May 30—June 3**

A legal holiday on May 30 will not affect existing plans.

Reservations must be on standard forms and cleared through the A.W.W.A. office.

June

23—New Jersey Section Outing, Wanaque, N.J. Secretary, C. B. Tygert, Box 178, Newark 1, N.J.


SERVICE LINES OF COPPER
Save you Time and Money
COPPER TUBE service lines installed over the years in all sections of the country have proved their dependability. They have justified the use of non-rust copper for underground service and have established their economy through maintenance savings.
Today, more than ever before, copper water tubes are used for water distribution within homes and buildings. Surely the line from main to meter should have equal durability.
Type K Anaconda Copper Water Tubes are furnished soft in 60-foot coils by wholesale distributors throughout the country.
4909
ANACONDA
from mine to consumer
Anaconda
COPPER TUBES
THE AMERICAN BRASS COMPANY
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if the water tastes "swampy"

Be prepared to combat successfully the odorous compounds that will be flushed down to your water intake by high spring waters. Here's what we recommend you do: Run Threshold Odor Tests regularly and stock up with an adequate supply of Aqua Nuchar Activated Carbon. In this way, Aqua Nuchar applications can be started promptly and in high enough dosages to adsorb quickly the intense tastes and odors that develop so suddenly.

To help you when these emergencies arise, stocks of Aqua Nuchar are spotted throughout the country in storage warehouses. Experts from our Technical Service Department are also available to study taste and odor problems at no cost or obligation.

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CLEVELAND 14, OHIO

Journal

AMERICAN WATER WORKS ASSOCIATION

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April 1949
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Contents

Labor-Management Relations in Water Utilities.....THOMAS F. NEBLETT 305

Lactose-Sulfanilamide Medium for Reducing Number of False Positive Presumptive Tests, *abstract*.....W. L. TIDWELL & O. A. BUSHNELL 308

Antipollution Measures in Pennsylvania.....FRANCIS J. GAFFORD 309

Synthetic Detergents.....T. E. LARSON 315

Philadelphia Ozonation Plant.....ELBERT J. TAYLOR 322

Installation and Maintenance of Gate Valves.....MAX K. SOCHA 331

Free Residual Chlorination in Indiana
RICHARD H. COOTE & MARSHALL P. CRABILL 337

Relation of Plankton to Hydrographic Conditions in Sweetwater Lake
MARTIN W. JOHNSON 347

Standard Specifications for Elevated Steel Water Tanks, Standpipes and Reservoirs 357

Departments

Cover Story .....*text p.* 330
Officers & Directors ii
Division & Section Officers iv
List of Advertisers vi
Coming Meetings viii
Percolation & Runoff 1
Membership Changes 28
Condensation 50
Service Lines 76
Section Meeting Reports 80

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Labor-Management Relations in Water Utilities

By Thomas F. Neblett

A paper presented on Oct. 29, 1948, at the California Section Meeting, Riverside, Calif., by Thomas F. Neblett, Labor Relations Consultant, Los Angeles.

THE problems of union activities in water utilities will be much less serious if personnel matters are handled properly. Whether or not to recognize a union or sign a contract is not the most significant labor relations question which management faces from day to day. If the employees want a union they will have it. If they want to send a committee to see the management, it will probably see them. As Robert Littler, San Francisco attorney, has pointed out, employers should not make the error of believing that their labor troubles arise solely from the agitation of union leaders. All men are discontented and there are always grievances in any establishment. Usually the union merely gives volume and power to the mutterings which have been going on all the time.

A management leader should not wait for the employees or a union to complain, but should take the initiative. He must lead lest he be pushed.

Personnel Methods

People can pretty much be divided into three general groups: [1] those whose work is drudgery but whose play is fun; [2] the dullards whose work is a bore and whose play is worse; and [3] those well adjusted personalities who get satisfaction in their work and are happy at home and elsewhere. This classification may be oversimplified, but from the author's observations the problem of the individual personal adjustment of each employee should be listed as number one in initiating a personnel program. It immediately suggests three of the most important steps in a well managed employment system:

1. *Careful selection of personnel.* Water is tested and approved before being served to the public. There is just as much reason to prevent a disruptive employee from poisoning the morale and efficiency of an organization.

2. *Placement.* Placement problems should be treated from the point of view not only of management but of the employee as well.

3. *On-the-job training.* Men's minds are never static. Every man can learn something every day, and it is just as easy to acquire good characteristics as bad. A happy man is one who feels he is going somewhere. Training may lead to transfers, promotions or replacement.

Any one of these topics is worthy of lengthy consideration. In connection with the last point, it might be mentioned that the principles of psychosomatic medicine—which aims at the adjustment of the individual, in mind and body, to his job and home environment—are under rapid development in industry, private as well as public. Doctors or psychologists trained in this highly specialized form of medicine devote their full time to it.

Individual recognition, not wages, is the most important factor in good personnel relations. By recognition is meant more than just seeing an employee and knowing who he is, although many employers or even immediate supervisors can not give the full name of each employee in their department, not to speak of being acquainted with his background, family, interests or ambitions. The workingman in a democracy most of all wants to be a member of a team, and he wants to improve himself and his family's status. Recognition—like morale, as any morale officer in the last war will testify—involves a thousand little things, each one of which has a personal connotation.

Every utility should set up grievance machinery, a procedure for orderly, step-by-step appeal on any dispute, no matter how large or small. It is essential to assure each employee that he has no cause for fear, that his problem will be dealt with fairly. Such procedures are in existence in most utilities, and employees should be kept informed of them and know the rules. A well handled grievance system can be the ounce of prevention or the safety valve which prevents an explosion.

It is not intended to give the impression that wages are unimportant. Low wages and poor working conditions will lead to dissatisfaction. The greatest cause of dissatisfaction with wages is the feeling of employees that others are getting better pay for doing the same work.

Keeping in mind the fact that most men are discontented and that this springs from man's natural desire constantly to raise his status, emphasis should be given to the opportunities each employee has to advance if he will apply himself diligently and improve himself by further training.

Constant comparison of a utility's personnel system with the prevailing practice in the industry and the area will indicate whether equal treatment is being given the employees. Every effort should be made to keep abreast of the trends and employees should be kept informed about their comparative standing. If outside standards cannot be met, a reasonable explanation might very well be made. Likewise, if a utility's standards are higher than the general level, the management would be justified in expressing its pride of superiority.

A consideration of labor-management problems brings up the subject of differences in employer-employee relations in public and private industry. As a

thorough discussion of this topic has been presented by the author in a previously published article (1), only a brief treatment of it will be given in this paper.

A private enterprise is measured in terms of profit, which governs company policy on the cost of labor or materials. In public employment the profit motive is removed and there is no incentive to cut labor costs to the point of organized employee resistance or other mutual aid and protection. In the field of utilities, however, the pressure from the consuming public for the highest quality of service at the least cost tends to minimize this economic difference.

Legal Distinctions

Important legal distinctions also exist, which in part recognize the economic difference and in part reflect the American concept of government. In general, public officers do not have the same freedom of action as private employers in dealing with unions. The authority of public officials is derived from their ultimate employer, the people. In California, for example, a government utility may not sign a contract with a union of employees without proper legislative sanction.

The issue involved was clarified in March 1948 when an injunction was granted by a California superior court restraining a union from striking or picketing a municipal utility. Strong public sentiment would oppose such actions by government employees. In New York, Governor Dewey sponsored an act providing forfeitures by striking public employees in that state; and in California, a bill (SB 949) to make such strikes a misdemeanor was passed by the Senate on May 15, 1947, only to die in an Assembly committee.

Striking against the government undoubtedly will be held illegal because the terms and conditions of employment are fixed by law and not by private contract and because the public welfare and vital public services would be affected. These principles have almost equal practical validity for private utilities such as water works.

There are other legal distinctions. Federal law and the California state code protect the right of employees in private industry to join a union and to bargain collectively. Such protection does not exist for public employees, nor are public officials required to recognize the union or to bargain or sign a contract.

Despite these differences, it must be conceded that in one fundamental way all employees are identical—they are human. It would be unwise for public officials to hide behind legal technicalities instead of dealing forthrightly with the problem. Both private and public officials will find that they have discretionary powers broad enough to cope realistically with almost any situation which may arise in either union activity or individual employee affairs. Collectively and individually employees react reasonably when treated in an equitable manner.

It is generally accepted as sound policy and practice to permit employees, both private and public, to join a bona fide union. There are, of course, exceptional classifications, such as policemen or guards. And the term "bona fide union" is used advisedly, because no employee can expect to exercise his democratic rights while at the same time joining a Communist-dominated union dedicated to the destruction, by force if necessary, of the very form of government which protects them and

to the liquidation of the free enterprise system which offers him the full opportunity of gainful employment. Any employee forfeits his right of employment who advocates, or who joins an organization which advocates, the overthrow of the government by force or violence.

Any employer would be playing into the Communists' hands, however, if he labeled all unions Communist dominated. Great care should be exercised so that recognized democratic rights of union activity are not denied employees who are proceeding in good faith and are not in opposition to the public interest.

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Lactose-Sulfanilamide Medium for Reducing Number of False Positive Presumptive Tests

By W. L. Tidwell and O. A. Bushnell

Abstract of paper submitted in partial fulfillment of requirements for degree of Master of Science at University of Hawaii, by W. L. Tidwell, Dept. of Bacteriology, Univ. of California, Los Angeles, and O. A. Bushnell, Dept. of Bacteriology, Univ. of Hawaii, Honolulu, T.H.

The authors have studied a primary fermentation medium developed for the purpose of eliminating "false presumptives." The medium consists of 1 per cent lactose broth to which 0.01 per cent (100 ppm.) of sulfanilamide has been added. Brom-thymol-blue is added as an indicator. The medium inhibits some of the lactose-fermenting spore-forming organisms. As the medium does not prevent the growth of *Proteus, Pseudomonas* species and *B. Polymyxa,* it thus does not eliminate all false presumptives. The authors' investigation showed no inhibition of coliform organisms. JOURNAL readers may obtain a copy of the report of the investigations by Tidwell and Bushnell if they request it by writing to the Editor, JOURNAL AMERICAN WATER WORKS ASSOCIATION, 500 Fifth Avenue, New York 18, N.Y., enclosing a stamped (6¢), addressed envelope for reply.

Antipollution Measures in Pennsylvania

By Francis J. Gafford

A paper presented on Oct. 21, 1948, at the Joint Meeting of the Four States and Western Pennsylvania Sections, Philadelphia, by Francis J. Gafford, Deputy Attorney General of Pennsylvania, Harrisburg, Pa.

IT has been aptly stated that "we must destroy water pollution or it will destroy us." This truth was fully recognized by the legislature of Pennsylvania almost fifty years ago when it passed the "Purity of Waters Act" of 1905 (P.L. 260). The effect of this statute, which declared it a misdemeanor to discharge sewage, without a permit, into the waters of the commonwealth, was to make such action a public nuisance if the sewage was discharged into any running stream, whether public or private. Long before, however, the courts of Pennsylvania had upheld this principle, for, as stated by Justice Shaffer, later Chief Justice of the Supreme Court of Pennsylvania, "it has always been under our law a nuisance to pollute a stream from which the public gets its supply of water."

Despite this early recognition of the evil of water pollution, the complexity of the problem has increased with the advancement of human progress. It is a paradox that the very factors which are indispensable to that progress are responsible for the existence of the problem: the increasing density of the population and the concentration of industry with its ever increasing expansion, intensity and diversification. From the standpoint of both population and industrialization, Pennsylvania is second only to New York among the states. More than 19,000 manufacturing concerns in Pennsylvania produce over 300 separate products, resulting in the creation of many sources and many types of pollution. Each general type has distinctive effects on human activities and requires a special technique for its abatement. Science has not yet discovered practical methods to combat all of these varieties of pollution. Their severity increases with the growth of population and industry. If that severity is not lessened, it will destroy them both, for the life of both depends upon maintaining and preserving the purity of a limited water supply as against virtually an unlimited number of pollutional agents.

Pure Streams Law

Legal protection of public water supplies against pollution was first given by the courts, prior to specific statutory enactments on the subject, under the common law doctrine of public nuisance. The doctrine was held to be applicable irrespective of how the public obtained its water, whether as customers of a water company or as riparian owners along the stream having the right to its reasonable use and the preservation of its natural size, flow and purity. As was once judicially emphasized: "It is the use of the water

by many people that makes its public use in applying the nuisance doctrine, not the fact of how the water is taken from the stream for their use, whether in the mains of a water company or by them in buckets."

In 1937 the legislature of Pennsylvania passed the first, and the presently operative, general antipollution statute, which is frequently referred to as the "Pure Streams Law" (P.L. 1987, 35 P.S. Sec. 691.1 *et seq.*). It is very comprehensive in its scope and designates the Sanitary Water Board as the paramount state authority charged with the duty of protecting the waters of the commonwealth from pollution by the discharge therein of sewage, industrial waste, or any noxious and deleterious substance which is or may become inimical to the public health, to animal or aquatic life, or which may prevent the use of the waters for domestic, industrial or recreational purposes. Any such pollution is expressly declared to be against public policy and to constitute a public nuisance. The Sanitary Water Board is authorized, after due notice and public hearing, to promulgate and enforce reasonable orders and regulations for the protection of any source of water approved by the secretary of the department of health as a present or future public water supply. The board may prohibit the pollution of such water supplies, not only when injurious to public health, but also when "objectionable for public water supply purposes."

The Pure Streams Law has been amended but once. In 1945 the General Assembly extended the scope of the original act, particularly with respect to acid mine drainage. The amendatory measure (P.L. 435) expressly made unlawful the discharge of such drainage into "clean waters" of the commonwealth "devoted to public use at the time of such discharge." Moreover, acid mine discharges may not be made to "clean waters," even when not devoted to public use, unless the commonwealth, under certain conditions, failed to construct and place in operation a diversion system for such drainage within a specified time, not to exceed one year, as fixed by the Sanitary Water Board.

Pennsylvania's antipollution law has long been nationally recognized as far in advance of that of any other state (1).

Significant Adjudications

Since the adoption of the Pure Streams Law, there have been some significant adjudications handed down by the courts of Pennsylvania. One of the most important of these was rendered by the Court of Common Pleas of Allegheny County in the case of *West Penn Water Company* v. *Sunnyhill Coal Co.* The plaintiff was a corporation which supplied water to approximately 8,300 people in the boroughs of McDonald and Burgettstown and in surrounding areas in Allegheny and Washington Counties.

In 1942 the coal company began strip mining operations in a water basin, between 5 and 6 square miles in area, which furnished the water company with its supply. In three years the coal company had mined approximately 150 acres of coal and covered about the same acreage with spoil piles created by its operations.

In 1944 the mining operations caused a cut to be made into an old abandoned mine on the watershed, with the result that 10 mil.gal. of mine water, which had accumulated in the deep mine, was re-

leased and seriously contaminated the water company's reservoir. Various methods were tried and studied in an endeavor to reduce or eliminate the pollution of the water supply, but to no avail.

The water company waited until April 1945 before it sought relief from the courts by a preliminary injunction. The case presented a dilemma: Such an injunction is only granted to prevent the occurrence of an imminent and irreparable injury, but the irreparable damage had already occurred. To restrain the coal company from strip mining would not relieve the situation, for the entire water basin was covered with open cuts and exposed high walls which would continue to be a source of contamination of the water supply. It would be impossible for the coal company to fulfill an injunction ordering it to restore the property to the condition it was in before the contamination took place. The court properly concluded that, as the water company's water supply was completely and permanently destroyed, no preliminary injunction could be granted.

In September 1945 the case came before the court for final hearing. After thirteen days of hearing the water company's evidence, the court advised the coal operators that unless an out-of-court settlement could be made which would enable the water company to procure an entirely new water supply, a mandatory injunction would be issued forthwith. Consequently, a $500,000 settlement was made by the coal operators (*2*).

On February 2, 1947, at a cost of approximately $700,000, a new water supply was put in operation. This figure was about $200,000 more than the settlement, but the expenditure of the excess amount resulted in a new water supply which was superior to the old and thus was a substantial victory for the water company.

Also significant, by reason of its contrasting result, was the case of *Punxsutawney Water Service Company* v. *Saricks* et al., which was tried in the Court of Common Pleas of Clearfield County almost immediately following the *West Penn* case. Here again, application was made to the court by a water company for a preliminary injunction to enjoin the defendant coal operators from strip mining in the drainage area of the water company's reservoir, in order to prevent its pollution by acid mine drainage. In this case, the relief was asked for promptly. The strip mining operation had commenced in August and the water company had learned of it in September and filed its suit in October. Only about 5 acres of coal had been mined out of a strippable area on the watershed of approximately 500 acres.

Immediately upon the filing of the suit, the court granted the preliminary injunction. At a subsequent hearing, the Court dissolved the injunction on the ground that "imminent and immediate danger" to the water company's supply had not been shown. On appeal, the Supreme Court of Pennsylvania sustained the court below, leading to one expression of opinion that the only effective way to prevent the ruination of water supplies by acid mine drainage is by legislative action forbidding coal-stripping operations on watersheds which are the sources of public supplies (*2*).

An interesting case was brought before the Sanitary Water Board in 1947 on the protest of the municipal water authority of the borough of Minersville

against an applicant for a permit to operate a strip coal mine in Schuylkill County. The authority owned no land on a 4,000-acre watershed draining into a stream on which it had erected two dams. These dams provided reservoirs which furnished the normal water supply for the Minersville area, where the average daily consumption was 1 mgd. Two small auxiliary sources of supply were derived from two reservoirs on tributaries of the main stream, which were drawn upon only when the chief supply was inadequate.

The applicant proposed to strip-mine approximately 400 acres of the land on the watershed, which he had leased from a riparian owner on the main stream. The beginning of the mining operation was to be near the top of a ridge and was to proceed toward the main stream. The plans provided for a diversion ditch to be dug on the hillside, parallel to but below the mining excavation, which would catch all the acid mine drainage discharged by the stripping, carry it to a point beyond the water authority's chief reservoirs and then discharge it into the stream.

The authority objected on the grounds that: [1] the proposed diversion of the water from the drainage area would result in the diminution of one-tenth of its water supply and [2] the diversion project was inadequate to prevent pollution.

When the matter came before the board on a second hearing, it was relieved of the necessity of making an adjudication, because the water authority had bought out the interests of the stripper and his lessor.

In a case involving sewage pollution, but not a public water supply, the Court of Common Pleas of Monroe County, in *Commonwealth* v. *East Stroudsburg Sewerage Co.*, admitted that the defendant company was committing a nuisance by discharging untreated sewage into a running stream which rendered it a menace to public health. It was further conceded by the court that the company should be enjoined from future operations which would contaminate the stream. The court did, in fact, enter an order restraining the company from discharging such sewage into the waters of the stream in question but granted almost a full year for the company to comply with the injunction and added that, if the company could not comply by the end of that time, the court would, on cause shown, extend the date of compliance.

One of the most interesting cases, also involving sewage pollution but not a public water supply, was that of *Commonwealth* v. *Borough of Dravosburg* which arose in Allegheny County. An individual developer of land was engaged in the erection of about 250 dwellings on a tract in the borough of Dravosburg. He laid out plans with streets and under them put in a sewerage system to accommodate the homes to be built by him. The borough approved the plans, accepted the dedication of the streets to be public highways and, at the developer's request and upon his oral agreement to pay the expenses of constructing the sewer system, applied to the Sanitary Water Board for a permit to dispose of the sewage as provided for in the plans. The permit was at first refused, but subsequently granted. Thereafter the developer sold the last of his 250 new homes and left without completing the sewerage system in accordance with the permit. A nuisance and a menace to public health resulted, and the state

attorney general filed a bill in equity for its abatement.

The borough contended that the sewers were not a municipal responsibility but were the private sewers of the developer, because the recorded dedication of the streets in his plans did not mention specifically the sewers that were to be built under them before the borough's acceptance of the dedication. The court held that, since the borough was the applicant for the permit, it thereby acknowledged, by implication at least, that it was the owner of the sewers. The court further added that: "The highest of good faith is expected, and in fact required, where a municipality or an individual negotiates with a statutory agency of the sovereign, particularly where those negotiations deal with matters of public health."

In its final decree, the court awarded a mandatory special injunction against the borough, directing it to complete the sewer system in accordance with the permit issued to it by the Sanitary Water Board, and ordered the developer to reimburse the borough for the costs of completing the work. Appeals to the Supreme Court of Pennsylvania were subsequently withdrawn, so that the decision of the Allegheny County Court became the final adjudication in this case.

There is now pending in the Superior Court of Pennsylvania a criminal case, *Com.* v. *L. Sonneborn Sons, Inc.*, et al., brought under the Pure Streams Law, which involves the discharge of pollutional oil refinery wastes into the Allegheny River. It is the first time that the Pennsylvania antipollution law has come before the appellate courts in its criminal aspects.

Other Antipollution Measures

Aside from legal enforcement, much is being and has been done to regulate pollution in Pennsylvania. An outstanding example, in the field of sewage pollution, is the Allegheny County Sanitary Authority, which was created under the Municipal Authorities Act of 1945 (P.L. 382), for the collection, treatment and disposal of sewage and admissible industrial wastes of municipalities, industrial establishments and persons situated in the area to be served by the authority. Agreements for participation in the preliminary study and plans of the project were made with 101 municipalities and 30 industries. The plans were approved by the Sanitary Water Board on May 20, 1948, and final agreements are now being negotiated by the authority looking toward the consummation of the project. This is one of the largest projects of its kind ever conceived and its completion will involve a cost of more than $80,000,000.

The Schuylkill River Desilting Project is the most notable attempt to reduce pollution from mining wastes. This river, which a hundred years ago was called the "beautiful, blue Schuylkill," is today jet black from the accumulation of millions of tons of fine coal. In 1945 the legislature passed an act (P.L.1383) making the Water and Power Resources Board the agency of the commonwealth to carry out the project. The act states that the commonwealth's responsibility involves the dredging of the river above the Norristown Dam, at an estimated cost of $15,000,000 to be expended over a period of six years; the federal government's responsibility is deemed to include the dredging of the river between Norris-

town and Philadelphia at an estimated cost of $10,000,000. Operations on this project are now under way.

As a further means of reducing the pollution from mining wastes, the legislature in 1945 also passed the "Bituminous Coal Open-Pit Mining Conservation Act" (P.L. 1198), which, among other things, requires the posting of a $200 per acre bond for the backfilling of stripped bituminous areas. A similar act, entitled the "Anthracite Strip Mining Law" (P.L. 1095), was passed by the 1947 session of the legislature to cover anthracite areas. That session also appropriated (P.L. 1177) more than $1,000,000 for the Department of Mines to seal abandoned coal mines in order to protect streams from acid mine drainage. In addition, the Sanitary Water Board has engaged the Mellon Institute to conduct research to discover other practical ways of combating this type of pollution.

Other research projects which are being conducted by the Sanitary Water Board include one by the Pennsylvania State College in the field of slaughterhouse wastes, one by a firm of Boston engineers in the field of pulp and paper wastes, and one by the Academy of Natural Sciences of Philadelphia. The last is a biological stream survey to test the soundness of the principle that living organisms in any given stream are useful indicators of the degree of its purity. Should this project establish the superiority of biological standards, it might well result in future changes being made in those presently in use. Current standards, as applicable to the treatment of industrial wastes, are divided into two general classes. One is a degree of treatment equivalent to primary treatment of municipal sewage and requires the removal of practically all settlable solids and at least 35 per cent of the organic pollution. The other standard is equivalent to complete treatment of municipal sewage and requires the removal of practically all suspended solids and at least 85 per cent of the organic pollution.

In addition to the regulation of pollution of streams within the commonwealth, Pennsylvania has joined her sister states in three separate interstate compacts to control the contamination of three interstate rivers: the Delaware, the Potomac and the Ohio.

Conclusion

As Justice Holmes said in his opinion for the U.S. Supreme Court in the case of *New Jersey* v. *New York:* "A river is . . . a treasure. It offers a necessity of life that must be rationed among those who have the power over it." That necessity is made available through public water supplies. The realization of this truth was a driving force in the execution of a program that has placed Pennsylvania in advance of every other state in the preservation and improvement of the purity of its streams.

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Synthetic Detergents

By T. E. Larson

A contribution to the Journal by T. E. Larson, Head, Chemistry Subdiv., State Water Survey Div., Urbana, Ill.

PERHAPS the most informative general description of "soapless soaps" (synthetic detergents) is the statement that they are compounds similar in composition to soaps and with similar properties, but with larger variety, permitting greater variation and control in providing a compound more specifically suited to an express purpose. Both true and "soapless" soaps are characterized by the combination of a long-chain organic segment insoluble in water and a water-soluble group, thus permitting a molecular orientation between water and soil. Soap is distinguished from "soapless soap" only in that the water-soluble segment of the former consists of the carboxyl group. Both are included in a broad group of chemicals called surface-active agents.

Surface-Active Agents

Surface-active agents are compounds which modify or affect the face layer of one surface in contact with another, whether the surfaces are air and water, oil and water, glass and water or any surface between two distinct bodies. These agents may have the properties of wetting, dispersing or emulsifying, but a particular agent may not be equally effective for all three purposes. Some excellent wetting agents are useless for emulsifying, or they may wet metal better than wool, or the reverse. Also, a good wetting agent may not foam in rain water but foam profusely in salt water. On the other hand, good emulsifiers may have little or no wetting or cleansing properties.

Surface-active agents which combine the properties of wetting, dispersing and emulsifying are called detergents and are cleansing agents. A good detergent should: [1] be soluble to some extent; [2] permit penetration of the water solution into capillaries by lowering the interfacial tension (*wetting*); [3] break up or separate particles which have agglomerated and gathered together (*dispersing*); and [4] link the dirt or oil particles with the water (*emulsifying*) rather than with each other or with the substance being cleaned.

Soap, being a wetting, dispersing and emulsifying agent, is therefore a surface-active agent and a detergent. Other surface-active agents are synthetic; that is, they consist of built-up or manufactured compounds not readily found in nature. There are synthetic wetting, foaming or emulsifying agents. Synthetics which combine all three of these properties are called "synthetic detergents" or "soapless soaps."

Soap is sometimes used primarily as a wetting or an emulsifying agent and not as a detergent. Soap as a wetting agent may easily be inferior to

a synthetic surface-active agent designed as a wetting agent for a specific or even a general purpose. Under another set of conditions soap may be found superior. Different soaps and synthetic detergents vary in effectiveness for different purposes.

Unfortunately, soap is also a softening agent. Actually soap must first soften water before it can become a detergent. Except for extremely hard water, the quantity of soap required for softening alone is less than the quantity required for cleansing or detergent action.

The use of soaps is limited by the fact that the calcium, magnesium and heavy-metal salts of the soap acids are highly insoluble and that the soap acids themselves are insoluble in acid solutions. Soap, therefore, cannot be used in many industrial processes where wetting agents or emulsifying agents or detergents are required. These deficiencies also limit the desirability of soap as a detergent for household use.

Synthetic surface-active agents were specifically devised for the purpose of providing industry with compounds which would have the desirable properties of soap but not the undesirable ones. It is therefore to be expected that industry will consume the bulk of the production of the synthetic surface-active agents, as distinguished from synthetic detergents.

The future of synthetic detergents in household use will depend not only on economics but to a large extent on their relative detergent properties and will be enhanced by the absence of the insoluble calcium and magnesium salts. Among the several reasons for the recent influx of synthetic detergents into household use are the high price of tallow and the shortage of coconut oil. The shortages were so severe that almost any cleanser could be sold.

It has been estimated that 125,000,000 to 150,000,000 lb. of synthetics was produced in 1946, as against 100,000,000 in 1941, 65,000,000 in 1939 and zero in 1928. In July 1947 the estimate was near 250,000,000 lb., and plant facilities built or under construction would have an additional capacity of 125,000,000. In time the production will be approximately 5 billion pounds annually.

This prediction does not mean that the 3 to 5 billion pounds of soap produced annually will be entirely replaced. A very sizable proportion of this production will be consumed by industry (dyeing, textile, electroplating, pulp treatment, paper making, pigment, insecticides, ceramics, metal cleaning, bleaching, dairy and dairy farming, breweries, dry cleaning, rug cleaning, sanforizing, canning, cosmetics, printing inks, latex, rayon and embalming). The proportion for household purposes may be very small, however.

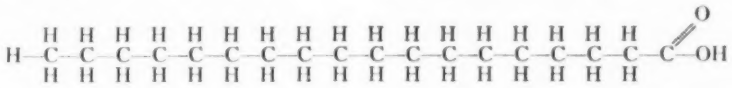
Chemical Structure

There were more than 200 surface-active agents other than soaps in 1943, and recent estimates report 300 in existence. Four or five types are used as detergents.

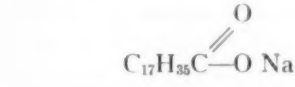
These types are not too dissimilar from soaps in structure. It should be of interest to note that soap itself was probably the first surface-active agent, prepared in prehistoric times by mixing wood ashes with rancid or scorched fat. Much has been learned and written about soap and its properties, and the development of the synthetic detergents rests firmly on this foundation of knowledge. It is appropriate,

therefore, to review the properties of soap and indicate which of them have been altered in synthetic detergents.

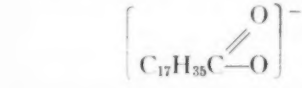
Soaps are salts of organic acids such as stearic acid:



The soap sodium stearate:

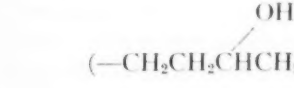


is called a salt because it is composed of a negative portion:



and a positive portion, Na^+. The series of carbon atoms is called a chain and is often designated by "R," as in:

Other soaps may have carbon chains of greater or lesser length; they may be branched or contain double bonds ($—CH_2CH = CHCH_2—$) in the chain; or they may contain hydroxyl groups:



in the chain. The variety is appreciable.

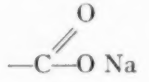
The carbon chains are akin to those found in gasoline, oils, fats and greases. Because of their similarity there is a greater degree of solubility for this end of the compound in the latter substances and a greater repellant action on the other (water-soluble) end of the salt. A definite orientation of the soap can thus be pictured at an interface between oil and water. The size and structure of the chain control the effectiveness of each of the surface-active properties of soap under specific conditions.

Carbon chains of less than eight carbon lengths are not even considered as soap since their surface-active properties are not sufficiently pronounced. Eleven-carbon and thirteen-carbon chains have a greater wetting power, but seventeen-carbon chains are not greatly soluble in cold water. The seventeen-carbon sodium stearate is, however, more soluble and more active in hot water (140°F.). A double bond in the stearate increases the cold-water solubility. Soaps having two or three double bonds, or a double bond and a hydroxyl group, are less effective detergents since the spacing offers a shorter chain length and poorer balance between water solubility and oil solubility. Such soaps have a greater attraction for water and are good wetting agents but poor dispersing and emulsifying agents.

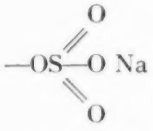
To be effective, soap should be used at a pH above 10. This means that some extra soap is required even in soft bicarbonate waters to neutralize the bicarbonate alkalinity and permit a pH increase to 10. Alkaline soap builders or additional reagents are often used to increase the effectiveness of soap.

The synthetic detergents were devised [1] to be effective in neutral or acid solutions, [2] to be effective in hard waters without softening and [3] to be effective without forming an insoluble calcium or magnesium soap in hard water.

One type of synthetic detergent is an aliphatic sulfate. Here the water-soluble (carboxyl) group:

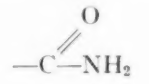


has been replaced by one which is more soluble in water:

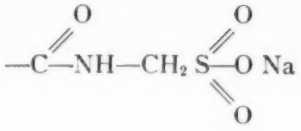


These compounds are effective in neutral or acid solutions and are not precipitated by hard water. The carbon chain is twelve to eighteen in length. The cost per pound for the synthetic detergent is higher than that for a similar soap, but its effectiveness is increased, and its cost lowered, by the addition of as much as an equal weight of sodium sulfate to reduce the solubility and thereby increase the emulsifying action. The length and splitting of the chain alters the detergent properties, and sometimes the limited addition of calcium salts increases the detergent action.

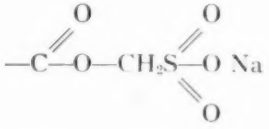
Another type of synthetic detergent is the sulfonated amide of the ordinary soap acid. Here the water-soluble group has been altered first to form:



and then to form:

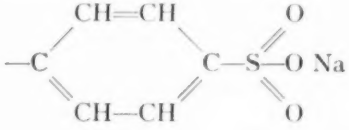


This is a good detergent and is not precipitated by calcium and magnesium. A similar type is the sulfonated ester:



but the latter is somewhat less stable in acid solutions.

A third important type is the alkyl aryl sulfonates made from petroleum derivatives. The water-soluble group is replaced by an aryl sulfonate:



The carbon chain alters the properties: three-carbon-chain compounds are excellent dispersing agents, ten- to sixteen-carbon-chain compounds are washing and foaming agents and the longer chains are emulsifying and even softening agents. These are good detergents, being stable and having varied properties. They are relatively cheap themselves and may contain as much as 65 per cent sodium sulfate to increase their detergent action.

A fourth type is the quaternary ammonium salt in which the water-soluble group is replaced by $—NR_3Cl$ or $(—NR_3)_2SO_4$. The negative portion is inorganic (Cl^- or SO_4^{--}) in nature

and the positive portion organic, $(R\,NR_3)^+$. This type is designed primarily for acid or neutral solutions and is equivalent in detergent properties to soap in alkaline solutions. It does not react with calcium or magnesium.

Several other less general types are available, such as partial esters of polyalcohols, alkyl aryl ether sulfates and even alcohol amine salts of the fatty acids or of the sulfated aliphatic alcohols. Essentially the development of synthetic detergents has multiplied the number of surface-active agents and increased their use for varied purposes.

Effectiveness of Detergents

The question in the mind of every housewife is which cleanser to use and assumes that one product will serve every household purpose. The question in the mind of the water engineer, plant superintendent and chemist is what is the effect of synthetic detergents on the desirability of soft water. A clear, indisputable answer to either of these questions is hardly possible.

Several reports in the literature are significant, however. It has already been mentioned that the synthetic detergents do not form insoluble salts or scum with hard water, a decided advantage in their favor. It has also been noted that, for any type of synthetic, the wetting, dispersing and emulsifying powers are different for each compound within the group. The detergent ability also varies from one compound to another, not only with the dirt to be removed (soil, rust, oil, fat or soot) but also with the material to be cleaned (crockery, metal, paint, enamel, skin, cotton, wool or nylon). Although the range of desirable relationships between the wetting, dispersing and emulsifying properties may not be great, it is unlikely that any one detergent, whether a soap or synthetic detergent, will be the most satisfactory for all purposes.

The interpretation is further complicated by the fact that the surface-active properties and the detergency of each compound within the several types are greatly affected by the addition of salts. The quality of the water —its mineral content and hardness— is therefore a factor to be considered.

Effect of Water Quality

One laboratory report (1) on detergency with the sodium salt of a sulfated alcohol showed three units of soil removed from cotton by a 0.1 per cent solution of the synthetic in the absence of any minerals. By the addition of calcium chloride in a concentration of 60 ppm. (as Ca), this compound removed ten units of soil; 120 ppm. (as Ca) removed eleven units; and 240 ppm., 9 units. The addition of sodium chloride in concentrations of 500, 1,800 and 50,000 ppm. (as NaCl) removed 7, 12 and 6 units of soil, respectively.

The same report includes data on another compound in a concentration of 0.15 per cent. The addition of 500, 1,800 and 50,000 ppm. salt (as NaCl) removed 4, 6 and zero units of soil respectively.

Commercial brands of synthetic detergents are built up or aided by the addition of neutral salts, in concentrations up to 80 per cent of the product, to increase the detergency properties. Other brands are mixtures of compounds of the same type to broaden the range of applicability.

One product, as shown by laboratory experiment, provides a greater dishwashing capacity in hard water than in soft water. A similar product was shown to require a lesser concentration than that of a "high-titre" soap for washing wool in soft *or* hard water. Cold-water washing of woolens with the synthetic was as effective as hot-water washing, an obvious advantage. The use of too much of the detergent was as ineffective as too little, but the range of desirable concentration was not too narrow to be impractical. The same product was not as effective in washing cotton as soap. In fact, it has been reported that no synthetic detergent has yet improved on soap for washing cottons.

Recent reports (*2*), however, indicate that the use of carboxymethylcellulose (CMC) with certain synthetics reduces or prevents the redeposition of soil particles once they have been removed from cotton garments.

The comparison of synthetic detergents with soaps may take the form of the curves shown in Fig. 1. Three synthetic detergents may exhibit different and nonuniform detergent properties with respect to hardness, in accordance with the relative curves in Fig. 1. The position of each, as well as of the soap, may change depending on whether it is used for dishwashing, laundry, woolens or bathing. The only safe interpretation is to say that specific synthetic detergents can be made more effective than soap in hard water.

There is in Illinois a crying need for synthetic detergents for use in small homes and farms with a private water supply having a mineral content of 1,500–2,500 ppm. and a hardness up to 2,000 ppm. Office correspondence with one individual indicated that commercial synthetic detergents gave a wonderful lather with his well water but were useless for washing or laundry purposes.

One municipality of 25,000 population uses water of 500–1,100 ppm. hardness, depending on the location in the city and on the season. A tavern keeper across the street from the water plant has found no commercial synthetic detergent which will permit his glassware to drain clean. He has a cistern with fine soft water but the health authorities will not permit its use.

Some private investigations show that more synthetic detergent is required for producing a lather than soap, which is understandable for some waters. It should be obvious, however, from the preceding discussion that the comparative ability to form a lather is *not* a true or satisfactory method of indicating the cleansing or detergent property of a soap or synthetic compound, since the ability to produce a foam is only one factor—and sometimes only a very minor factor—in detergency.

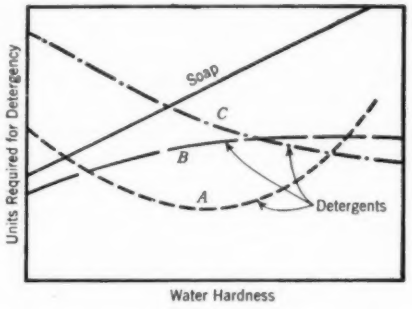


FIG. 1. Comparative Efficiency of Soap and Synthetic Detergents

Conclusions

Soaps and synthetic detergents are similar chemical compounds. Syn-

thetic detergents have the overall desirable advantages of forming soluble salts and of being effective in cold water and at a neutral pH. Either may be more effective for specific purposes and in particular waters. For instance, at present soap appears to be more desirable for washing cottons in warm soft water than synthetic detergents in any water. There is no soap or synthetic detergent which is superior for all domestic purposes in all waters.

Superior synthetic detergents are a reality for certain purposes (for example, washing woolens, nylons, silks or glassware in moderately hard water). The producers are generally to be complimented in refraining from specific references to the superiority of their products for many uses, although the general tone of the advertising implies that they are universally superior.

There appears to be a need for package labeling to indicate the water quality for which each product is satisfactory and the purposes for which it is designed. If and when this is done, soap savings data for soft water may become obsolete. Until then the number of beneficiaries of the synthetic detergents will be limited by the quality of the water and by the purposes for which the products are used.

Improved synthetic detergents have superseded and will continue to replace soaps, as well as the early "marvel" synthetic products, for many purposes. Nevertheless, the advantages of soft water are so many and varied that even if soap savings data were made obsolete (as a result of improved and cheaper synthetic detergents) it is highly doubtful that the soft-water industry would be bothered.

References

1. DREGER, E. E. ET AL. Sodium Alcohol Sulfates. Ind. Eng. Chem., **36**:610 (1944).
2. STENERSON, HARRY. Behind the Markets. Chem. Eng. News, **26**:488 (1948).

Philadelphia Ozonation Plant

By Elbert J. Taylor

A paper presented on Oct. 22, 1948, at the Joint Meeting of the Four States and Western Pennsylvania Sections, Philadelphia, by Elbert J. Taylor, Chief, Bureau of Water, Philadelphia.

THE history of ozonation which may be associated with Philadelphia dates back to 1905, when D. Rivas, then assistant bacteriologist of the Philadelphia water department, experimented with a plant erected by the United Water Improvement Co. The experiments were conducted with the water of the Schuylkill River, below the city, at 30th and Locust Streets in West Philadelphia. The results obtained in bacterial reduction, coli destruction and oxidation of organic matter were excellent.

Between 1905 and 1939 experimental plants were operated for various lengths of time by at least five different municipalities in America, none of which adopted ozonation. Plants were built by seven other municipalities, but all except two were later abandoned.

It was pointed out (1) in 1916 that, despite the effectiveness of ozone, the mechanical difficulties and high cost would have to be overcome before the treatment could be adopted very generally. The development of better engineering materials and techniques, however, has made the consideration of large ozone generating plants practical today.

On October 18, 1939, the city council of Philadelphia appropriated $10,000 for the construction of a 1-mgd. pilot plant to test the use of ozone in Philadelphia water. The pilot unit was built at the Lower Roxborough plant, which obtains raw water from the Schuylkill River. It was operated from March 13, 1941, to April 6, 1942, on slow sand filter effluent.

A small pilot plant of 2-gpm. capacity was also operated at Lower Roxborough from September 14 to December 6, 1941, and at Torresdale—on Delaware River water—from February 19 to April 6, 1942. It was then moved to Belmont and operated from April 17 to September 18, 1942.

These studies, which were carried out in close cooperation between the manufacturers of ozone equipment and members of the water bureau staff, produced information which materially advanced the knowledge of ozonation, at least in this country.

In September 1946 an inspection was made at the Whiting, Ind., plant, where ozonation was producing good results on a water difficult to treat. It was found that the plate type of aluminum electrode units originally installed were hard to keep in operation; however, the new tubular units then in use seemed, because of the life of the electrode units and the methods and frequency of servicing, to be practical for large installations.

As a result of these studies, and after public hearings had been held before the Public Works Committee of the city

council, the water bureau obtained permission in August 1946 from the Pennsylvania state department of health "for the construction and operation of an ozonation plant for taste and odor reduction at the Belmont Filter Plant of the City of Philadelphia. This plant will apply ozone to the presettled water ahead of the mixing chambers and coagulation basins for the rapid sand filters." The contract for equipment was awarded to the Welsbach Corp., Philadelphia, of which the Ozone Processes Div. is a subsidiary.

The contract specifications were more functional than detailed, and the design detail in nearly every phase of the development has been of a pioneer nature, since only the generator units are proprietary equipment of the contractor. Furthermore, no plant more than one-sixteenth the size of the present one had ever been designed with such units in the United States. Installation was delayed until fulfillment of contracts for structures but is now virtually completed. [*The ozone generators, which with their accompanying equipment cost $600,000, went into operation on March 14, 1949.*—Ed.]

Plant Design

In consideration of the needs of the Philadelphia plants, it seemed that the Belmont Rapid Sand Plant should be the site of the ozone installation. This is the only plant in the system where any water filtered through rapid sand filters alone is delivered to distribution without mixing with slow sand effluents. Taste and odor reduction in rapid filters is ordinarily much less than in slow filters. The present rapid sand filter capacity is 36 mgd., a moderate size of plant. As the largest existing modern type of ozonating plant in America was only adapted for a capacity of 75 lb. a day, or one-sixteenth of that required at Philadelphia, it seemed desirable that the design should be developed on the basis of such a moderate-capacity plant. The ground areas available are so located that the installation will fit into the ultimate plant layout. The planned doubling of the number of rapid filters and the plant capacity may require no additional ozone capacity, but, if more is needed, there is space for increased development of the installation.

The existing plant provides presedimentation of the river water for roughly 20 hours, with alum pretreatment if the turbidity is high. One-half of the total next passes directly to slow sand filters and is then postchlorinated and distributed by gravity. The other half passes through a 48-in. pipeline to an open channel where alum, lime, carbon and chlorine are applied successively, before it enters the baffled mixing channels and settling basins; this treatment is followed by rapid sand filtration and postchlorination. The effluent of the twelve 3-mgd. filters passes into a 1-mil.gal. clear-water basin, from which an average of 6 mgd. is pumped directly into the Belmont High Service Dist. The remainder flows by gravity through a 48-in. pipe, which also picks up the effluent of several slow sand filters before passage either to gravity distribution or to a filtered-water basin.

The ozone is to be applied after the 20-hour presedimentation period. Water in this stage of treatment was found to require an average of 1.6 ppm. ozone, with the maximum not exceeding 4 ppm. The latter figure was adopted as the basis for the ozone-generating capacity required, which was specified to total 1,250 lb. per day.

Ultimately twelve more rapid sand filters will be provided, after which all

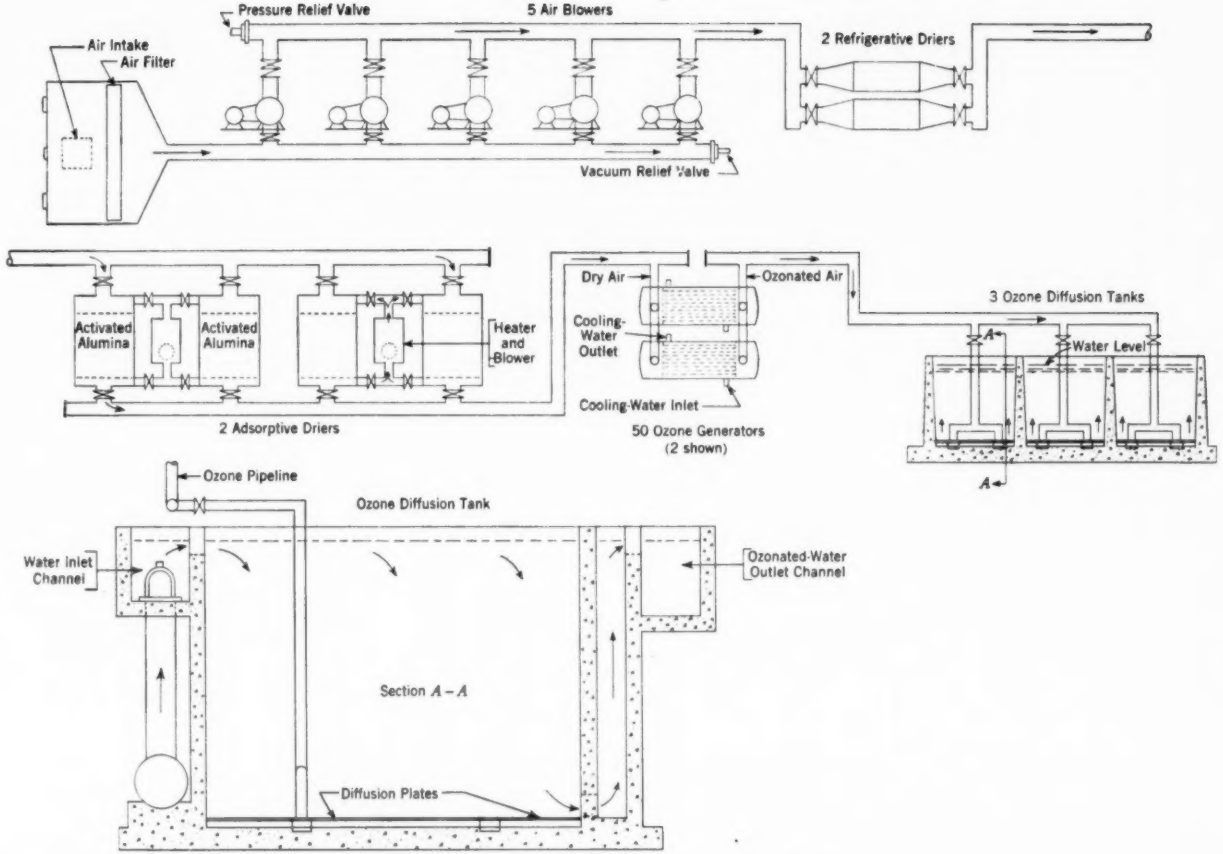


FIG. 1. Schematic Layout of Ozonation Plant

water in this plant will be double-filtered. At that time it is expected that new ozone diffusion tanks will be installed to ozonate all the water after rapid sand filtration but before slow sand filtration.

A special building has been constructed to house the generating equipment. A partition separates the building area into two sections, one containing the air supply equipment, the other the generator units. Air blowers are arranged in line along an outer wall, taking air from a common header. The header is supplied by an air filter receiving the air through a wall opening provided with louvres. Refrigerative and adsorptive driers are placed along the partition wall. High-voltage switchgear also is located at one end of this section.

In the other section, the generator units are mounted in two banks, two units high, one bank being thirteen units in length (26 units in all), the other bank, twelve (24 units in all). In one corner, an office-laboratory is provided where 24-hour chemical control of the entire Belmont Filter Plant is practiced.

Stepup transformers for the individual generator units are mounted on the roof, in pans provided with drain lines to a French drain.

The one-story structure is of architectural brick, with all concrete floors. A parapet extends above the roof, shielding the roof-mounted transformers from view.

Ozonation Process

Air contains a large percentage of oxygen, a molecule of which is made up of two atoms of oxygen. The production of ozone requires the breaking up of oxygen molecules and the formation of molecules composed of three oxygen atoms. Actually, ozone is produced by the passage of air through an electrical corona, or what may be termed a silent electrical discharge between two electrodes. The potential between the electrodes is approximately 15,000 v. and for each pound of ozone produced, 8–9 kwhr. of current is required by the generator, plus 2–3 kwhr. for the operation of auxiliary equipment.

In the Belmont plant there are 50 ozone generators, each capable of producing 25 lb. of ozone per 24 hours, the total capacity being 1,250 lb. per day, or (at atmospheric pressure) approximately 9,400 cu.ft. Not all of the oxygen in the air is converted to ozone; in fact, it is economical to convert only 0.5–1.0 per cent of the total weight of air. This means that the total amount of air which must be circulated through the generators, when operating at the maximum capacity, equals 1,500,000 to 3,000,000 cu.ft. a day.

To obtain reasonable efficiency in generation—and to prevent corrosion—all of this air must be dried before passage to the generator units. Dirt removal is also essential to prevent coating of the electrodes. The air is cleaned by passing it through an electrostatic air filter. The pressure is then boosted by air blowers to overcome friction losses in pipelines, generators and diffusion plates, as well as the water pressure over the diffusion plates. Next the air passes through refrigerative and adsorptive driers, which remove its moisture. After being dried, the air flows through a steel line to the generator units. The ozonated air then goes to the diffusion tanks.

In the diffusion tanks a maximum of 36 mgd. of water will enter over adjustable weirs at the top of one side of the tanks and pass downward and across the tank, while the ozonated air (1,500,000 to 3,000,000 cu.ft. a day) will be introduced under porous plates at the bottom of the tanks and will rise through the 18-ft. depth of water. Better than ten minutes' nominal retention of the water is provided in these tanks. After reaction with materials in the water, the residual ozone in the outgoing water may be determined and the dosage controlled accordingly. The sequence of units with relation to the path of air flow is indicated schematically in Fig. 1.

Generator Units

Each generator unit, guaranteed to produce 25 lb. of ozone a day under the operating conditions imposed in the design, consists of a shell and two stainless steel headers, between which run 85 parallel tubes of stainless steel with a 3½-in. inside diameter. Flanges are welded on the ends of the shell, and header plates are bolted to them. Each of these is provided with a glass port for observation of the coronas formed.

Dried air enters at a header section, where electrical contacts to the electrodes are placed. An outlet of equal size, similarly placed is provided in the opposite header section for the ozone. Cooling water enters the bottom of the shell near one header, with a like outlet at the top near the other header.

Within each of the 85 tubes is placed a Pyrex glass tube, open at one end only. Since the tolerances on the stainless steel tubes were greater than on the glass tubes, spacers of different thicknesses were used to produce continuous annular dimensions. These spacers were cemented to the glass tubes, on the job.

A graphite coating on the inside of the glass tube acts as one electrode, the steel tube as the second. A corona is formed by the continuous electrical discharge in the annular space between the outside of the glass and the inside of the steel tube. Through these annular openings all air must pass from one header of the unit to the opposite header, and it is during this passage through the corona that ozone is produced. Ozonated air leaving the second header section joins with the discharge of the three other units in a riser and flows to the stainless steel collector header placed over the bank of generators.

A paneling enclosure is provided for each bank of units, extended from the floor to a height of 9 ft., and effectually concealing the miscellaneous equipment. Doors of suitable size give access for good servicing. In the panels are placed push-button electric controls; valves to shut off the air, ozone and water; and rotameters to indicate air flow.

Diffusion Tanks

As it leaves the generating units, the ozonated air is collected into a single 10-in. stainless steel line which runs underground to the diffusion tanks. One valved branch line passes downward into each of the three tanks, where it branches into a distribution channel formed in the concrete floor of the tank. The ozonated air is distributed into a shallow chamber beneath porous plates, passing upward to diffuse throughout the 18½ ft. of water above. Each of the plates is supported off the bottom on three stainless steel bolts, with washers at the heads, which were cast in the concrete

bottom. Joints between the plates were poured with hot Bitumastic.*

The elevation of water in the tanks is governed by an electrically operated butterfly valve in the 42-in. supply line. This valve is ordinarily controlled from the elevation in a flume of the old plant to which the ozonated water discharges. However, pressure lines from the influent flume of any one of the three tanks may supersede the ordinary control to cause a reduction of flow, if necessary to prevent the tank from overflowing.

Water entering over weirs at one side of the top of the tank passes downward and across the tank to five outlets under the wall at the opposite side. At maximum flows, the theoretical detention time in this contact section is ten minutes. After ozonation, the water passes to a flume of the old plant, where chemicals are added for coagulation.

Air Supply Equipment

The 4-sq.ft. air inlet through the building wall is protected by louvres. Air enters an electronic precipitator through the side of a steel cabinet-like enclosure. These precipitator units may be removed from the cabinet for replacement of the filter tissue. Electrification of the filter tissue is accomplished from a power pack mounted on the cabinet side. The rated capacity of these units is 2,000 cfm.

The air blowers are rotary, positive-displacement, noninternally lubricated, heavy-duty units, each rated to deliver 440 cfm. of air (measured at atmospheric pressure) against a discharge head of 10.5 psi. Each blower is driven through multiple V-belts by a 30-hp. motor, mounted, with a belt-tightening device, on the welded-steel base provided for both the blower and motor.

The number of air blowers in service will vary between two and four during ordinary operation, depending on the required amount of ozone to be produced at the time. Schedules of operation will be modified after complete checking of the operating and generating efficiencies of the plant as a whole. Since full-capacity generation could be accomplished with three blowers operating, the standby capacity provided is two units, or over 60 per cent.

The two refrigerative driers, placed in parallel connection, are each equipped with a compressor driven by a direct-connected 25-hp. induction motor. The capacity of each of these units is 2,000 cfm. of (free) air; cooling to approximately 50°F. removes moisture in excess of 50 grains per pound of dry air. Since Philadelphia's atmosphere may contain 140 gr. of moisture per pound of dry air (a condition reported on August 13, 1947, at 65 per cent humidity and 91°F.), this step in the process represents a required removal of as high as 90 gr. per pound. Either refrigerative unit is sufficient for full-capacity plant operation, and, therefore, 100 per cent standby capacity is provided.

The adsorptive driers, which remove the remaining moisture, are standard units made by the Kemp Co., Baltimore, Md. Each of the two identical units has two steel tanks, containing activated alumina of ¼-in. to 8-mesh size. One of the tanks may be regenerated while the other is in operation. Since the capacity of each tank is 1,000 cfm., the full designated generation capacity of the plant would mean a concentration of 1.08 per cent

* A product of the Koppers Co., Inc., Pittsburgh, Pa.

ozone if only one tank were in operation, unless the unit were operated above its rated capacity. Because in an emergency one unit would carry the plant, the other may, therefore, be considered to furnish 100 per cent standby capacity. When plant generating capacity is approached, however, greater efficiency of operation will probably result from operating both units at reduced capacity.

The amount of moisture in the air will be indicated, and recorded, by a dew point recorder. Before the passage of too much moisture occurs, the flow of air will be shifted to the other tank while the used alumina is "reactivated," which consists only of drying it semiautomatically. The air flow must be diverted by manual operation of valves. The drying cycle is then started by a push-button control which places a recirculating blower and a 90-kva. air heater unit in operation. Heated atmospheric air is circulated downward through the alumina until the temperature at the bottom of the material reaches 250°F. The heater then shuts off automatically, but the blower continues to operate, circulating air within the water-cooled unit until the temperature of the alumina has been lowered sufficiently. The blower then cuts off, and the tank is ready to be placed in service again.

At a rate of 1,000 cfm. of air while removing from 50 down to 1 gr. of moisture per pound, tanks should operate more than eight hours before redrying is necessary. The redrying process should require about 7½ hours. One unit of two tanks, therefore, provides for operation 24 hours a day, and two units, of two tanks each, will furnish a capacity of 2,000 cfm. continuously.

Services and Controls

Water for cooling is taken from the high-service line at the pumping station, located practically across the drive from the ozone building. An 8-in. cast-iron supply line is run to one of the pipe galleries of the ozone building where an 8 × 4-in. Venturi tube is placed, with a recorder provided on the meter panel. The cooling-water demand of each refrigerative unit may run to a maximum of 70 gpm. and that of an adsorptive drier, to 15 gpm. Cooling water from the generator units is picked up, joined by that from the driers and discharged into the coagulating basins. The total water use at capacity production, including the drier, may reach approximately 1.00 mgd.

A new 13,200-v., 60-cycle, three-phase service from the local power line is provided to a single-throw, oil circuit breaker, with 220-v. solenoid operation and overload trip coils. An auxiliary line for breaker operation is also available from the nearby high-service pump station. Transformers step down the 13,200 v. to a 460-v., three-phase, 60-cycle service for a total loading up to 750 kva. The 460-v. current from these transformers is used throughout the controlled circuits of the plant, except for the lighting service. Three 5-kva. transformers supply a 120-v. current for lighting, metering and recorder apparatus and for service outlets.

To forestall the possibility of all equipment being put out of service by the opening of one circuit breaker, two breaker circuits are provided; to one are connected three of the five blowers and one each of the two refrigerative and the two adsorptive driers. Circuit breakers and line starters for these auxiliary units are all

mounted on the wall at one point, but push-button controls for every unit are present at the individual unit.

The three single-phase circuits for the generator units are each connected to a separate wall-mounted switch cabinet containing sixteen or eighteen switches, each of which controls the current to the contactor of an individual generator. From the contactor, the 460-v. current feeds to a Type S distribution, single-phase, oil-insulated, self-cooling transformer on the roof, which steps the voltage up to 15,000 volts. High-tension or secondary connections are made direct from the transformer to the electrode of the generator unit, avoiding cumbersome and expensive high-voltage switching equipment.

Ozone generators act as condensers, and the resulting power factor would normally be something like 60 per cent leading. To avoid such an upset in the local power system, for which the city would be penalized, reactors are shunt-connected on each primary circuit to the high-tension transformer.

Circuits to individual generator contactors are energized with the closing of a switch in the wall cabinet, which flashes a green light on the control panel at the front of the unit. Pushing the start button on this panel will close the contactor and place the unit in operation. A red light will go on if the contactor closes and remains closed; otherwise, only the green light will remain lit. The latter, therefore, indicates that the circuit is energized to the individual contactor; the red light, that the generator unit is operating electrically. The unit may be cut out of service by pushing the stop button at the unit or by opening the switch in the wall cabinet.

To prevent the destruction of generator electrodes through overheating, two devices are incorporated in the design. A pressure switch is connected from the air-header end of the generator unit and wired into the control circuit of the contactor. This switch will not allow the contactor to be closed unless air pressure is present in the generator. Serious overheating of units due to lack of water circulation is not likely so long as water is present in the shell; however, as a protective measure, a thermostatic switch is inserted in the water in the shell.

As a safety measure, to insure either workers or unauthorized persons against electric shock, the access or service doors are all equipped with safety switches. These, like the pressure and thermostatic switch, are wired in series in the contactor control circuit.

Instruments record the flow of treated and cooling water, the air flow, the air and water temperatures in headers supplying generator units, the dewpoint of the air after drying and the amount of current used. Additional indicating instruments are provided for control and checking purposes.

Operational Procedures

The operation of this plant will yield a great deal of information on large-scale ozone generation which has heretofore been unavailable—for instance, the most efficient concentration to be generated, the average amount of current required per pound of ozone produced, the life of the various units, the amount and cost of maintenance required, and the practicability of instal-

lation of such a manufacturing plant by a municipality.

Any program set up now will, no doubt, be altered with experience. In general, the planned treatment procedure will be to vary the number of generators in service with the changes in the rate of flow through the contact tanks and the changes in the ozone demand of the water, so that there will always be a slight residual in the effluent of the contact tanks. As the ozone demand of the water will ordinarily not change rapidly, the variations will be largely those occasioned by changes in the rates of filtration, which will be reflected in the rate indicator reading at the meter panel. Residuals will be checked frequently throughout the day by the plant chemists.

It is planned to record and study data on the concentrations of ozone produced, the poundage produced with different air flows, current use and other factors, in order to determine the most efficient generation and the most practical and economical operation procedures.

Reference

1. VOSMAER, A. *Ozone, Its Manufacture, Properties and Uses.* D. Van Nostrand & Co. (1916).

This Month's Cover

The dinner-plate view of the Philadelphia Water Works on the cover was one of a series—now much prized by collectors—of American scenes printed on Staffordshire ware by English pottery makers over a hundred years ago. Although designed for distribution in the United States, the particular plate depicted was in use as a wall decoration in an English cottage until its owner, Mrs. Jane Lee, sent it to the Association through a member of the headquarters staff.

The history of Philadelphia's water supply, which is brought up to date by the preceding paper, opens with a bequest in Benjamin Franklin's will earmarking part of £100,000 for the construction of a pipeline from Wissahickon Creek into the city. In 1801, eleven years after Franklin's death, a supply was developed along the banks of the Schuylkill and pumped approximately 4,200 ft. to the site of the present City Hall in "Center Square." At that point, according to an account by Francis S. Friel (December 1948 JOURNAL, Vol. 40, p. 1253), the water was lifted by booster pumps into wooden elevated tanks, from which it flowed by gravity into the distribution system of wood mains.

Presumably the building shown on the plate is the Schuylkill works and not the booster plant or some later construction; however, the comments and possible contradictions of better informed students of the times are cordially invited.

Installation and Maintenance of Gate Valves

By Max K. Socha

A paper presented on Oct. 28, 1948, at the California Section Meeting, Riverside, Calif., by Max K. Socha, Engr. of Water Distr., Dept. of Water and Power, Los Angeles, Calif.

THE primary function of gate valves is to start or stop the flow of gas or liquid in the pipeline. They do not take the place of check valves, altitude valves, regulators and other special types of valves, nor, except to a limited degree, are they used for throttling the flow of water. Gate valves should be designed to produce a minimum flow resistance in a wide-open position and to be operated with a minimum of effort even though such operation might very seldom be necessary.

There are many kinds of gate valves, each designed to meet the special requirements of a particular installation —square- or round-bottom types; rising or nonrising stems; hub end or flanged; gates equipped with bypasses; manually, hydraulically or electrically operated gate valves. The characteristics and advantages of each of these types in meeting a particular situation are well known and need not be discussed herein. Instead, this paper will discuss essentially the location, use, installation, records, maintenance and operation of gate valves by the Los Angeles Dept. of Water and Power. The department has developed methods over the years to utilize gate valves in the best manner to safeguard and facilitate the operation of the water system. It is hoped that the enumeration of these procedures will be helpful to the operators of smaller water systems who seek practical operational ideas and look to the larger organizations for the breadth of experience gained through the operation of complex systems.

The practices of a large organization, however, do not always fit the needs of smaller systems, which operate under smaller budgets and may not be required to meet the situations resulting from a complex system, varying topographical conditions, large service connections for industrial and other uses, and heavy traffic conditions common to large cities. It will remain for each water works operator to determine whether the adoption of the practices discussed hereafter will best fulfill his needs. For example, the department utilizes solid-wedge gate valves in sizes up to and including 8 in. and double-disc gate valves 12-in. or larger. These sizes have been adopted arbitrarily because large-scale purchases are required and heavy stocks of material are carried well in advance of installations, so that purchases are rarely made with a particular installation in view. Pressure conditions vary so widely throughout the system that it has been found best to limit the size of solid-wedge valves to 8 in., in order to reduce the number of items carried

in inventory. The smaller operator, purchasing directly for a certain installation and encountering lower pressure conditions, might well employ solid-wedge valves in the larger sizes with a substantial saving in cost.

Location

The location of gate valves controlling the grid system should be determined by the number of consumers who would be without water or sufficient fire protection as the result of an outage of any portion of the water system. Every effort should be made to reduce the inconvenience to a minimum and, if possible, to limit shutdowns to single sections between intersecting streets. Such an outage might be due to the failure of a main through deterioration, damage from an outside source or unequal settlement, or to a broken fire hydrant or a planned shutdown to make connections or repairs to the system. Valves should be so located at the intersecting mains that an outage of any portion of the system will not require the operation of more than six or seven gates, and preferably less. In rectangular grid systems gate layouts at intersections could be arranged to produce shutdowns of single blocks by the closure of only two or three gates, unless pressure and flow conditions require the partial closure of additional valves to reduce the pressure differential. The cost of such an ideal arrangement, however, may not warrant such close control. As there can be no set plan for gate valve arrangements, any new extension of the system must be studied in relation to the existing system and an attempt made to approach the ideal arrangement.

Gate valves in large feeder or trunk lines should be located in such a way that any portion of the line may be isolated for planned shutdowns and repairs while still maintaining adequate feeder supplies to the rest of the system supplied by the feeder main. Auxiliary feeder lines supplied by the trunk line should be so arranged, with respect to the trunk line valves, as to bypass any isolated section of the trunk line and, if possible, provide reverse flow on the downstream side of the shutdown section of trunk line up to the closed gate valve.

In parts of California the wet-barrel type of hydrant is used, as severe freezing weather is not encountered. It has been the policy of the city of Los Angeles, for the last few years, to install gate valves on all fire hydrant laterals, to eliminate the necessity of shutting off an entire block of consumers to repair fire hydrants. Traffic hazards on heavily traveled streets and around driveways, parking lots, markets and the like make this arrangement particularly desirable. However, the mere installation of a gate valve on a fire hydrant lateral may not always facilitate shutoff for repairs. An incident recently occurred in Los Angeles in which a truck was involved in a traffic accident, breaking off a fire hydrant and overturning so that it rested directly on top of the gate valve operating well. The police officer at the scene refused to allow moving the truck so that the gate valve could be closed. It was necessary to shut down the entire block completely to stop the flow of water at the broken hydrant. Water works operators depending upon gate valves on fire hydrant laterals should arrange to have proper instructions issued to police officers who may direct activities at the scene of a traffic accident.

Whenever possible, a consistent plan should be used in placing gate valves in the system. This will facilitate identifying and locating the valves in emergencies, particularly on dark or rainy nights. The valves should be installed so as to enable operation with the least effect on vehicular or pedestrian traffic. Most main-line gates are located on the property line (produced) at intersecting streets. It is an easy matter to determine this line on dark or rainy nights by sighting along the inner sidewalk line.

Fire hydrants are usually located in the beginning of curvature of the curb return at corners, or adjacent to it, or in the middle of a block. In the business districts or shopping areas, gate valves so located come within the lanes of pedestrian crosswalks and care should be exercised to maintain the gate caps flush with pavement surfaces. If the valve is leaking, repairs should be effected immediately. These precautionary measures are recommended to prevent a pedestrian from slipping while walking on or across wet pavement. Pedestrians may also suffer falls and injuries when traffic loads have caused a depression around improperly set gate caps. The expense of frequent inspection and repairs will be more than offset by the elimination of numerous damage suits against the water department. Neglected repairs to leaky valves located at pedestrian crosswalks may also affect water department public relations adversely, as fast traffic will often splash water from otherwise dry pavement on pedestrians standing at the curb.

Installation

Hub-end gate valves are installed on all cast-iron mains, and flanged-end valves are used on all steel mains, in conjunction with Dresser couplings. It is Los Angeles practice to install gate valves with a waterway diameter equal to that of the adjacent pipeline, up to 16 in. On larger pipelines, it is customary to install 16-in. valves on 20-in. lines, 20-in. valves on 24-in. lines and 24-in. valves on 30- and 36-in. lines. An attempt is thus made to strike a good balance between initial cost and ease of operation on the one hand and the maintenance of good hydraulic properties within the pipeline on the other. In order to keep head loss to a minimum, the gate valve assembly is equipped with reducers having a length not less than 2½ times the reduction in diameter or an angular reduction of approximately 11 deg. The enlarger section should have a length not less than six times the difference in diameters or an angular enlargement of approximately 5 deg.

Standpipes of 6-in. thin-gage pipe with cast-iron gate caps are installed on all gate valves up to and including 12 in. in diameter. Steel pipe varying in size from 30 to 72 in., with 24-in. cast-iron manholes, is used over the larger gate valves. This affords an opportunity to utilize old salvaged pipe which might otherwise go into the scrap pile. The operating nut is always set vertically so as to be accessible from the street surface. Geared gate valves set in the larger standpipes are protected from dirt by a hood made of impregnated heavy canvas cloth.

The standpipe (known as a well in some localities) should be centered over the operating nut and the bottom end set on blocks to prevent contact with the bonnet. Heavy casing resting directly upon the bonnet may, on heavily traveled roads, cut a groove in the bonnet and also cause a joint leak.

Where paving follows immediately after the standpipe is set, the standpipe is cut about 1½ in. short and set into position, and the backfill is tamped; as the pavement is laid the cap is settled down to permanent grade. If the pavement is concrete, the cement finisher runs the end of a small trowel around the edge of the cap to separate it from the concrete. When asphaltic material is used for paving, the standpipe is set similarly but is only of sufficient length to reach the first lift of pavement. The top of the pipe is belled out and a short sleeve is placed to provide for the next pavement course and obtain an exact grade setting, flush with the finished surface of the pavement.

Service Connections

All service connections 3 in. and larger, whether for domestic, commercial, industrial or irrigation use, are equipped with a gate valve at the water main, which can be used for the purpose of controlling the water when the main is tapped and which is also maintained as a permanent control valve for the service connection structure at the junction of the service connection and the main. It is important that the gate valve used for this purpose be a clear-way type in order that the tapping machine cutter will not be impaired in its operation by the gate valve wedge extending into the throat.

Within the last few years the flanged-outlet type of double clamp has been adopted for the main where the service connection tap is to be made, in order that the flange type of gate valve may be employed as a main gate for the service connection. This is rather an important point in the installation of a service connection as it makes possible the elimination of a lead joint between the water main and the service connection control valve, which has always been one of the major weak points of a service connection. Even when such bracings as yokes and rods are used, there is still the chance of total failure or the possibility of a leak of the lead joint at this point. With the use of the flanged gate valve and flanged double clamp on the main, all of this liability is eliminated; and, in addition, the solid permanent alignment of the flanged gate valve and fitting makes possible a more positive and accurate tapping operation of the water main. A definite alignment of the gate valve to the main is made possible, provided the machined flanged outlet of the double clamp and the machined surface of the flanged gate valve are in alignment with the horizontal axis of the main upon which it is installed. The use of flanged gate valves and flanged double clamps at the main has aided materially in the tapping operations for large water service connections.

In addition to the gate valve which controls the water through the service connection at the water main, two other valves are installed in the construction of a large service connection where only one meter is employed. A gate valve is placed immediately preceding the meter and is known as the curb valve. It is of the flanged type, in order to make possible a direct flanged connection to the metering equipment, and is used for the control of water to the meter. Another flanged gate valve, employed at the outlet of the meter, is used for the control of water from the property to the service connection at the time of the replacement or repair operations required on the water meter. This valve is used effectively in controlling backwater from large buildings, which otherwise would cause consid-

erable loss of time on repair operations and sometimes property damage, as the disposal of the water in a meter vault can be a difficult problem.

Maintenance

Keeping gate valves in good working order at all times is of the greatest importance. To achieve this objective, periodic inspection and operation are necessary. In trunk lines, all gate valves on the main line should be inspected and partially operated several times a year. This procedure should also apply to all gate valves in the business district. Gate valves in outlying districts should be inspected and operated annually. The gate men should keep in contact with street repair forces and see that gate caps are not covered over and that the standpipes are kept clean during street repairs. In an emergency, a covered gate cap could result in very costly damage and is unnecessarily inconvenient to consumers and the fire department. If the covered gate is on a fire hydrant lateral, a section of the main might have to be shut down, and, if a main-line gate, two sections of main would be involved.

In preparing to shut off a main for cutting in tees or crosses, the gates should be inspected several days in advance of the shutoff. A sample stem and at least one additional stem for each size and kind of gate in the system should be kept on hand in the tool room.

Corrosion sometimes occurs between the discs of bronze-mounted cast-iron double-disc valves when left in the open position for lengthy periods, and the valve may become inoperative. The best method of repair is to replace the iron discs and working parts with bronze discs and parts. The discs may also be removed, cleaned and sandblasted and then plated with cadmium or copper. If time does not permit this, the discs can be cleaned, dried by a gas torch and wire-brushed, and then two coats of Debecote * paint applied to iron surfaces.

When an asphalt-paved street is being resurfaced and the gate valve does not need repacking, the cap may be removed temporarily and a sack stuffed into the standpipe to keep it clean while the blade equipment is working. Short sleeves as required are used to bring the cap to grade.

Very often leaky packing can be replaced without excavating and removing the standpipe, if the packing box bolts are within hand reach from the street surface. This repacking requires the use of a knock puller for removing the operating nut from the stem, and extension sockets for removing nuts on packing box bolts. The packing box is cleaned out by slightly turning the stem. The water in the standpipe can be removed by using a suction gun or by soaking it up with rags.

Whenever a gate is excavated for repacking, the bonnet bolts should be inspected, as very often they are corroded and must be replaced. All bolts and iron nuts should be painted with a coal-tar base paint, and, if in corrosive soil, the gate should be backfilled with dry sand.

A gate valve may very frequently be difficult to operate because the clearance between the stem and the cast-iron gland and the follower is rusted tight; if so, it is best to excavate the gate, clean the stem thoroughly and replace the one-piece gland and follower with a bronze follower and a new gland.

* Made by the Debevoise Co., New York.

An improvement has recently been developed in gate caps making it easier for gate men to locate a gate. In the congested downtown area there are street intersections which have many gate caps for fire hydrant, service or feeder connections. The new gate caps used in this area show a brazed *H*, *S* or *F* on the black cast-iron face which is easily seen at night.

Gate Records

The size, make, number of turns and location of gate valves installed by the field forces are reported on regular forms. These data are field checked by the gate man of the particular district and then the information is ready for recording. The gate book records are a series of maps and detailed location sheets. A 12 × 12-in. loose-leaf binder using 11 × 11-in. sheets, printed on one side only, has been found to be the most convenient method for keeping these field records. By a coordinate system of numbering, the distribution system is divided into sections about 1 mile square, using a scale of 600 ft. to the inch.

Street lines are not shown on the gate book record maps because of the scale, and the pipe shown on the sheet locates the street. When a new gate is noted in the gate records it is given a number and is shown on the maps by a heavy dot. Each map section is bound in the book opposite a corresponding location sheet in tabular form which lists all gates shown on the map section. Each section carries its own series of numbers, and the number shown opposite the gate on the map is specifically located on the detailed location sheet. This description locates the gate from the curb line and property line in the street in which the main is situated and also the nearest cross street. In addition, information is given on the make and size of gate, the number of turns and whether the gate is a right- or left-hand one. When a gate is removed from the system it is taken off the maps and the detailed location sheets, making the number available for reuse.

The records show all main and fire hydrant gates. Service gates 4 in. and larger are also shown. Large pressure-regulating stations are shown in detail on special sheets using a larger scale. The congested business area is shown on maps with a scale of 300 ft. to the inch because of the numerous gates.

All gate and regulator men, construction foremen and superintendents have gate books covering their assigned districts. Complete system books are maintained in the administrative and engineering offices of the department. Gate record maps are maintained for the fire department and the fire underwriters' associations. Gates are not to be operated except by authorized persons and only after examination of the gate books.

Acknowledgments

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Free Residual Chlorination in Indiana

By Richard H. Coote and Marshall P. Crabill

A paper presented on April 22, 1948, at the Indiana Section Meeting, Lafayette, Ind., by Richard H. Coote, Supt. of Filtration, Water Works, Valparaiso, Ind., and Marshall P. Crabill, Asst. Supt. of Purif., Indianapolis Water Co., Indianapolis, Ind.

Valparaiso Experience—*Richard H. Coote*

THE Valparaiso Water Works serves a population of about 10,000. The per capita consumption has risen sharply, and total consumption was about 400,000 gpd. higher in 1948 than in 1946. This increase seems to be due to the construction of new homes, the enlargement of Valparaiso University and better overall financial conditions.

The principal source of supply is Flint Lake, 3 miles north of the city, where the 2-mgd. filter plant and the pumping station are located. The lake is approximately 90 acres in area, has a capacity of approximately 400 mil. gal. and is fed by a series of smaller lakes. Four wells are in operation and a new one is being built. When the construction is complete, a total of more than 2 mgd. of well supply will be available. Water from this source may be discharged directly into the clear well of the filter plant or fed into the lake to raise its level. The latter procedure is sometimes necessary when the rainfall is light and the lake level low.

The lake water intake is located about 300 ft. from shore in 30 ft. of water. Water flows through the intake by gravity into a raw water basin in the low-service pumproom, where chlorine and alum are added. The water is then pumped into an aerator and, as it leaves, lime and carbon are added during periods when tastes and odors are present. Better results are obtained by applying the carbon at this point rather than in the raw-water basin, and a saving in chlorine is accomplished. The water then flows into a mixing basin containing two horizontal mixers. After 30 minutes in the mixing unit, the water flows into a settling basin with a 30-minute detention time. During periods of high turbidities and odors in the raw water, properly treated water cannot be applied to the filters because the settling time is inadequate. It is anticipated that this condition will be corrected by the installation of a clarifier to increase the settling time to four hours or more. The water flows from the settling basin through a flume to three filters, each of 700,000-gpd. capacity, and discharges into a 70,000-gal. clear well. Postchlorination can be applied on the discharge side of the high-lift pumps which pump water into town, a distance of 3 miles.

The distribution system consists of 29 miles of mains and is noteworthy

for including about 10 miles of wood pipe, which, however, is being replaced as fast as materials can be obtained. Frequent taste and odor complaints have been traced to this part of the system, and, at the beginning of free residual chlorination, the wood pipe absorbed considerable amounts of chlorine. There are also frequent failures in these mains, causing interruption of service and constant work for the distribution crews.

Excessive Chlorine Demand

Early in May 1946 it was noticed that distribution system samples showed no residual chlorine, even though a residual of 0.45 ppm. was maintained at the pumping station. At that time more than 38 per cent of the samples from the plant tap and the distribution system showed positive presumptive coliform tests. The lack of residual chlorine and the doubtful bacterial quality warranted immediate investigation. Very low chlorine residuals were present in the water applied to the filters and none in the filter effluent.

Both the 1.2-ppm. prechlorination and the 0.48-ppm. postchlorination dose were gradually increased. By mid-July the application of 2.16 and 0.96 ppm. for pre- and postchlorination, respectively, resulted in a chlorine residual of 0.8 ppm. at the pumping station, but no more than a trace of chlorine residual was found in the distribution system.

A sample of finished water containing 0.8 ppm. residual chlorine was allowed to stand for ten minutes in the laboratory. No chlorine residual was present at the end of that time. Increasing the chlorine application to the full capacity of all the chlorinating apparatus—2.4 ppm. for prechlorination and 1.4 ppm. for postchlorination—produced a plant tap chlorine residual of 1.2 ppm., but the residual disappeared from the water in less than one hour.

By this time it was apparent that the chlorine demand of the water was not being satisfied by the amount of chlorine applied. The chlorine demand of the raw water was found to be 11.25 ppm. Tests showed that the high chlorine demand was due to organic matter released by weed growths in the lake. Under these conditions, laboratory studies indicated that a free available chlorine residual resulting from the "breakpoint" process would produce a stable residual.

Free Residual Chlorination

Chlorinating apparatus of a larger capacity was installed and free residual chlorination was started on October 2, 1946. By this time the chlorine demand had decreased to a point where it was exceeded by a prechlorination feed of 9.5 ppm. This application produced a residual of 3.0 ppm. in the water applied to the top of the filters. The residual in the filtered water was 1.0, 0.13 and 0.30 ppm. for Filters No. 1, 2 and 3, respectively. Mixed water from the clear well contained a residual of 0.45 ppm. free available chlorine. The water was postchlorinated to raise the residual to 1.5 ppm. in the plant tap. This condition lasted about 24 hours and then the full 3 ppm. appeared in the filter effluents and in the clear well. Postchlorination was stopped and the prechlorination dose was reduced to 7.5 ppm. This produced a plant tap residual of 2.0 ppm. free available chlorine.

A survey was then made of the distribution system. Ten or twelve

points were selected in different sections of the system and residual chlorine tests were conducted. In the north part of town nearest the pumping station, it was found that residuals of 0.75–1.0 ppm. free available chlorine were present. In the south, southeast and southwest sections, the residuals ranged from zero to a trace, and any residual present existed as combined available chlorine. After these findings the residual at the plant was maintained at 2.5 ppm. free available chlorine until residuals in these outlying districts were raised to 0.02–0.13 ppm.

It was established that the wood pipe sections of the system were absorbing chlorine at a very high rate. In districts where residuals could not be maintained, five or six blocks of main were shut off at night and were sterilized by the application of high-test hypochlorite solution sufficient to produce a chlorine residual of 50 ppm. When these mains were flushed before morning the water was very dirty and high in color and had a very bad odor. Samples taken before flushing and sterilizing showed a large amount of organic matter, but after this treatment the organic matter had disappeared or was much reduced. The chlorine residuals in these areas improved. If one treatment did not accomplish the desired results, it was repeated until residual chlorine was present.

Following the adoption of free residual chlorination, an immediate decrease took place in the proportion of samples showing positive presumptive coliform tests. From a high of 38 per cent positive samples from the plant tap in July, the positive presumptive samples dropped to 2 per cent by the latter part of October, and to none at all by the end of November. The percentage of positive distribution system samples dropped accordingly. For the year ending December 31, 1947, only two out of 1,258 samples from the plant tap were positive; and of 465 samples from the distribution system, only six were positive presumptive. These results provide an excellent demonstration of the bactericidal properties of free available chlorine residuals.

Taste and Odor Problems

At this plant, tastes and odors cause considerable trouble during the lake "overturn" in the spring and fall and during the algae periods in the summer. Since the sedimentation period available is short, activated carbon cannot be applied in sufficient amounts to be completely effective when tastes and odors are at their maximum.

Free residual chlorination was given a severe test when applied to the control of tastes and odors in this plant. Although the treatment does not remove all tastes and odors, laboratory studies during severe algae conditions showed that if combined residual chlorination had been in use, the tastes and odors would have been much more objectionable. A practical demonstration was provided in the distribution system; where free available chlorine residuals existed, the number of complaints was much less than in the areas where the residuals were combined available chlorine or where no residual was present. The water temperatures at the time approached 80°F., which was also a stiff test of the effectiveness of free residual chlorination.

During certain "overturn" periods, and again during an excessive growth of *Vorticella*, particularly objectionable

conditions have existed. Although the threshold odor value of the raw water was very low and the odor of the finished water was not strong, the water had a very bitter taste. The full capacity of the carbon machine was utilized, but the taste remaining was still very marked. By increasing the tap residual from 1.5 to 2.0 ppm., the taste was reduced enough to make the water palatable. When this condition was first experienced, it was thought that the taste in the raw water had subsided, and the chlorine application was reduced to normal. The taste reappeared in a few hours but decreased immediately when the chlorine feed was increased. Now, whenever these bitter tastes occur, the chlorine feed is immediately increased to provide a higher free available chlorine residual, and a definite improvement results. It is believed that when a longer detention period becomes possible in the settling basins, and when activated carbon can be applied in larger amounts, the practice of free residual chlorination will reduce tastes and odors to a minimum.

Prior to the use of free residual chlorination a green slime developed on the walls of the settling basin and filter troughs during the summer months. At such times the algae counts were not high but the growth was still marked. After adopting free residual chlorination, this growth disappeared and has not been noticed since, although the algae counts in 1947 exceeded 1,700 units.

In midsummer of 1946 and once again in 1947 white worms were found when flushing a dead end in a wood main, but none were obtained for examination. By sterilizing and flushing, the condition was eliminated for the rest of the summer. Some worms, identified as *Nais,* were found in 1947, however, in an area where no residual chlorine was present. When placed in water containing a 0.15 ppm. free available chlorine residual, they immediately became inactive. Two of the areas where they had previously been found were checked but none was present, and it was noted that these points had free chlorine residuals. It appears that if residual chlorine is present at the dead ends, as is now true, this condition will not recur.

Records

A graphic record is maintained of about twenty sampling points, showing the date of sampling, the chlorine feed and the chlorine residuals in the plant effluent and at the point sampled. These charts provide a cross section of the distribution system. If the residuals are too low or too high, the chlorine application can be adjusted accordingly. This record was a very great help in starting free residual chlorination, particularly in the wood main areas, as it supplied a clear indication of where the greatest amount of chlorine absorption was taking place and what the loss was at these points. The distribution system is still sampled at these selected points twice monthly. The charts are kept up to date and now reveal that the plant effluent residual and the sampling point residual curve are growing ever closer, implying that the loss of residual through the mains is decreasing. When free residual chlorination was begun, and for months afterward, a loss of 0.50–1.5 ppm. residual chlorine occurred in the mains at points where high residuals were found. At present an average loss of 0.35 ppm. residual chlorine is noted.

A fairly uniform residual can be maintained in the system without having excessively high residuals in outlying districts. This improvement has reduced the chlorine consumption and, correspondingly, the complaints from areas where the residuals were formerly high.

Public Relations Aspects

It is appropriate here to emphasize the value of good public relations. When free residual chlorination is substituted for combined residual chlorination, it is wise to explain the new undertaking to consumers. False rumors and misunderstandings frequently follow the inception of a new treatment. Any variation in taste or odor is likely to be attributed to chlorination.

At Valparaiso, as the free available chlorine residuals spread through the distribution system, tastes did develop through the action of these residuals on old organic matter in the mains. Complaints were most frequent during the first months of this treatment, in those parts of the system where organic matter was high and where the concentration of residual chlorine was low. In that section of the system where high residuals were first obtained, a chlorinous odor existed but caused few complaints. Occasionally consumer complaints about chlorine taste were found to be without basis and derived from the rumor that more chlorine was being added to the water. After several months specific complaints concerning chlorine tastes and odors practically ceased.

It has been demonstrated that a systematic flushing program is very beneficial in the control of tastes and odors. Consumers see this work being carried out, and its value should be called to their attention. Public relations may be so improved by an explanation of water purification problems and of changes in treatment that the consumers become sympathetic and less critical.

Variations in Application Rate

For the year ending December 31, 1947, the average application of chlorine was 9.0 ppm., the high point occurring in June, when the monthly average was 12.7 ppm. The low months were January and February, in which the average application was 6.2 ppm. The chlorine requirement shows a decrease as the absorption of chlorine in the distribution system decreases.

Free residual chlorination has not been difficult to control. The "flash test," which depends upon the rate of color development of residual chlorine with ortho-tolidine, has proved to be a suitable plant control test. In conjunction with the "flash test," the ortho-tolidine-arsenite test is employed for more accurate determinations of residuals. The production and maintenance of free available chlorine residuals is the valuable accomplishment of this method of treatment. It has been found that to select an operating range within which the free available chlorine residual may vary, and to change the rate of chlorine application as seldom as is necessary, will give the most satisfactory results. A range of 0.80–1.2 ppm. residual free available chlorine has proved satisfactory at the Valparaiso plant. On this basis, variation in the rate of chlorine application is required only infrequently; that is, when a considerable change takes place in the raw-water characteristics.

The improvements in water quality obtained by free residual chlorination at Valparaiso are significant. A considerably higher degree of disinfection has been attained, as demonstrated by the almost complete absence of positive presumptive coliform tests on distribution system samples. The palatability of the finished water has been markedly increased, in spite of the continued presence of taste- and odor-producing substances in the raw water. When more adequate settling units are provided, it is anticipated that water of even better quality can be consistently furnished.

Indianapolis Experience—*Marshall P. Crabill*

In buying something, no matter what, it is wise to consider the cost and weigh carefully the value received per dollar expended. If a chlorination process is contemplated, the prospective purchaser certainly wants to know whether or not it costs more than the method it is intended to replace. And if its cost is higher it must accomplish something more than the other process. It is obvious that more chlorine will be required to produce a free available chlorine residual than a combined one.

Cost Comparison

During 1946 the Fall Creek Treatment Plant at Indianapolis used 3.5 ppm. chlorine for free residual chlorination and produced a free available chlorine residual between 0.5 and 0.6 ppm. in the filter effluent. The same treatment required 3.6 ppm. in 1947. These figures are annual averages. If combined residual chlorination had been used to produce a combined available chlorine residual of the same magnitude, approximately 1.2 ppm. chlorine would have been needed. From this experience—and it has been much the same since 1943—it is evident that three times as much chlorine is now used for the treatment of Fall Creek water by the free residual chlorination process as would be required to maintain an equivalent combined available chlorine residual.

The White River Plant at Indianapolis used 5.9 and 5.8 ppm., respectively, during the same years to produce the same free available chlorine residual in the filter effluent. Here again approximately 1.2 ppm. chlorine would have been necessary to obtain a combined available chlorine residual of 0.5–0.6 ppm. Experience indicates that five times as much chlorine is required by the free residual chlorine process for treatment of the White River water as would be needed to maintain a combined available chlorine residual.

Taking both plants into consideration, it is apparent that between three and five times as much chlorine is now used in treating the water at Indianapolis. Along with the increased use of chlorine, additional chlorine feeding equipment is generally required. Although the annual average figures for chlorine use were 3.6 and 6.0 ppm. at the two plants, the maximum rates of application were 8.4 and 18 ppm. It is obvious that the maximum rates of application required will determine how much chlorine feeding capacity is needed. Free residual chlorination has been practiced at Indianapolis for about nine years, and, almost without excep-

tion, the maximum application rates have been required at some time during the year when particularly bad tastes and odors were present in the raw water. The treatment plant must be prepared to apply adequate chlorine in such periods; otherwise, full advantage could not be taken of the process. The additional feeding equipment required is not a small item of cost, but after the initial expenditure it does not recur. Taking into account the life of the equipment, its cost can be regarded as not too significant.

Compensating Factors

The increased consumption of chlorine and the necessity for additional feeding equipment will increase the cost of sterilization if free residual chlorination is used. But there are also factors which tend to compensate, at least in part, for the increased expenditure. At Indianapolis it has been found that, whenever free available chlorine residuals are present, the amount of coagulant required is reduced. This saving is easily confirmed in the laboratory by making batch runs. A batch run made on January 9, 1946, indicated that 15 ppm. of coagulant was required to produce a settled-water turbidity of 1.0 ppm., if the water was treated to obtain a free available chlorine residual. When less chlorine was applied, 21 ppm. of coagulant was required to produce the same settled-water turbidity. At times the saving of coagulant may be less than 6 ppm. and, rather infrequently, more but rarely is there no saving. The largest savings occur at those times when coagulation is most difficult, particularly when there is a great deal of organic matter or when algae counts are high.

Also tending to compensate for the cost of additional chlorine and equipment is the fact that seldom, if ever, does the Indianapolis supply require corrective taste and odor treatment other than the production of a free available chlorine residual. Not too many years ago—perhaps fifteen or sixteen—the literature in the water works field was devoted in large part to corrective treatment for tastes and odors. With earlier methods of taste and odor control, it was possible to reduce, mask or partly correct many of the most objectionable tastes and odors, but never quite so well as with free residual chlorination. In addition, these earlier methods of treatment were more expensive. Although this has proved true for the particular waters treated at Indianapolis, it is not intended to suggest that the same relative economy will obtain in all water treatment plants.

The most objectionable tastes and odors in the Indianapolis supply are due to the alga *Synura,* to gas plant wastes or to heavy rains flushing out barnyards and streams. *Synura* is known to cause a strong cucumber odor and also a taste that remains in the mouth long after the water has been swallowed. Both the odor and taste are completely eliminated by free residual chlorination. Gas plant wastes generally cause a coal-tar odor, and quite frequently chlorine must be applied to produce free available residuals of such a magnitude as to require dechlorination before the odor is removed. It is an expensive treatment but accomplishes results that no other corrective method has produced in the Indianapolis plants. Sewage, musty, river or fishy odors which generally accompany heavy rainfall ordinarily

require only the maintenance of normal chlorine residuals. In laboratory studies, many of the odors are found to be accentuated when chlorination is carried only to the point of producing a combined available chlorine residual.

It has been claimed that free residual chlorination produces an objectionable chlorinous taste in the treated water. Few consumers can determine by taste or odor whether the residual is free or combined available chlorine if the amount is 0.5 ppm. or less. Residuals in the distribution system will seldom exceed 0.5 ppm., except those very close to the plant. It is quite easy to distinguish by odor alone between the two types of residuals when they are as much as 1.0 ppm. or more.

In considering the costs of free residual chlorination, an increase in chlorine consumption and in the necessary capacity of chlorine feeding equipment has been recognized. It has also been established that there is a compensating saving in the use of coagulant and in corrective taste and odor treatment. Experience at Indianapolis indicates that the difference in cost between combined and free residual chlorination will be so small that it is not too important a factor.

Control of Process

Another question which should be investigated in considering the use of free residual chlorination is whether or not it will be more difficult to control this method. The fact that the literature of the water works field records the use of this process in more and more water treatment plants points to the conclusion that it is not difficult to control. This evidence could also be used to indicate that the cost is not an important factor.

An auxiliary well supply is used in Indianapolis to supplement the surface streams in times of drought. The application of chlorine required to produce a free available chlorine residual of 0.5 ppm. has not changed since 1941, except in one or two shallow wells. None of the wells is used regularly, but this does not indicate that the control of the process is troublesome.

It is known that the amount of chlorine required to produce a specific free available chlorine residual by this process is dependent upon the amount of ammonia nitrogen present in the raw water. The control of the process is therefore more difficult when frequent changes occur in raw-water ammonia and less so when the raw-water ammonia is fairly uniform. A lake or storage reservoir for raw water, such as is provided at the Fall Creek Plant, is a decided asset in simplifying control of the process. This plant was operated from July 1941 to May 1943 before the storage reservoir was in service. During that time it would have been impossible to obtain control of the free residual chlorination without frequent ammonia determinations in the raw water.

Initially these determinations were made every two hours by the plant operator, and chlorine rate changes were almost as frequent. As Fall Creek was then a small, flashy stream, changes in the characteristics of the raw water were frequent and of great magnitude. For example, with only a moderate rainfall, raw-water turbidities increased 500 ppm. in 30 minutes. Changes in alkalinity and ammonia nitrogen were rapid and sharp. Approximately 75 to 80 per cent of the stream flow was used by the plant. Control of the process of free residual

chlorination during those two years was particularly complex but was, nevertheless, successful because each of the plant operators had a thorough understanding of it. Even under extremely adverse conditions, this treatment need not be too difficult when the essential control determinations are properly applied.

After May 1943, when the 7.5-bil. gal. storage reservoir was filled, the control problem at the Fall Creek Plant was considerably eased. The long storage time and the biologic activity in the reservoir smoothed out the changes in the characteristics of the raw water. Particularly important was the fact that storage leveled off the ammonia nitrogen concentration to a reasonably uniform figure. Although the plant operators continue to make ammonia determinations, only four are made each day. The ammonia determination is seldom required for control of the chlorination process, and plant operation is based almost entirely on the Laux flash test for residual chlorine. The primary control point, at the downstream end of the flocculation unit, provides about 40 minutes' mixing and reaction time after the chlorine is applied and before the sample is taken for residual measurement. The 40-minute time interval is a little too short to indicate satisfactorily the progress of chlorination when water temperatures are low—that is, 35°F. or less.

Some organic materials appear to be attacked and oxidized by chlorine much more slowly than others, and at low temperatures the speed of all reactions is reduced. For such reasons, the flash test, or any other test, may show the presence of free chlorine when the contact period is insufficient to allow all reactions to proceed to completion. This free chlorine may subsequently be consumed as the reactions proceed, and what remains will be in the form of a combined available chlorine residual. The solution, of course, is to establish a regular second point of control which permits sufficient time for the slower reactions to be completed. The second control at the Fall Creek Plant permits the settled water to be tested two hours and 45 minutes after the chlorine has been applied. It has been thoroughly demonstrated that, at a point where free available chlorine is shown to be present by the Laux flash test, the water has been satisfactorily treated by the process.

Occasionally it has been found that the flash test indicates the presence of free chlorine but, at the same time, there is an almost imperceptible lag in the color development. In the winter of 1947–48 it appeared that the flash test indicated the water had been chlorinated to the extent of providing a free available chlorine residual, but the control test was termed a "slow flash." Actually the development of the color was much too fast to be due to combined available chlorine. On such occasions the residual chlorine curve would have shown an almost vertical drop just ahead of the breakpoint, and the curve would not drop to zero residual. Assuming this condition to exist, both combined and free available chlorine would be present in almost equal percentages. Then the ortho-tolidine reagent would show color development much more rapidly than when the combined chlorine is predominant, and much less rapidly than when free chlorine is predominant. At the White River Plant, control of the chlorination process presents almost the same prob-

lems that are now present at the Fall Creek Plant; that is, since the reservoir has been in service.

Taking all of the problems into account, the control of free residual chlorination is obviously more difficult than the control of combined residual chlorination. Even though not regularly needed, ammonia nitrogen determination will be an extremely helpful tool. It is helpful for the plant operator to have frequent breakpoint curve tests of the raw water and to understand them thoroughly. It is equally important for the operator to use and interpret the flash test correctly, or to have some other equally satisfactory control test. The new amperometric titrators provide even more complete information regarding the relative proportions of free and combined available chlorine residuals.

Elimination of Slime Growths

Experience at Indianapolis indicates that slime growths and biologic deposits have been eliminated from the filter sand and gravel since free chlorine residuals have been maintained in the filter effluents. Previous to the use of free residual chlorination it was standard procedure to remove the sand and gravel from the rapid filters at about two-year intervals. The gravel was always found to be slimy and the lower sand layers were sticky. This operation was not only a costly one but, while in progress, reduced the plant capacity for a period of several months. This reduction has assumed even more importance than the cost consideration in the past few years. The filters have not been disturbed during the last nine years, and inspection of the sand and gravel indicates that the slime and gum are not present. It would appear that a surface wash system, installed about nine years ago, has contributed somewhat to the better condition of the sand and gravel. It does not seem, however, that the surface wash alone should be credited with eliminating biologic growths. The elimination of filter cracks, mounds and mudballs is most likely due in part to surface wash and in part to the maintenance of a free available chlorine residual. The disappearance of slime growths in standpipes, elevated tanks and the distribution system might also be expected when free available chlorine residuals are maintained. These very results have been reported in the literature from several plants.

It is interesting to note that at infrequent intervals loss of head on the slow filters at Indianapolis has been reduced when the applied water is treated to maintain free available chlorine residuals in the effluent. This cannot be dependably accomplished at all times, but frequently, when loss-of-head increases cannot be considered due to increases in applied turbidities, an increase in the rate of chlorination will reduce the head loss and extend the period of filter service between washings. Apparently this treatment is effective when the filter stoppage is due to biologic growths, and this is exactly what is expected of chlorine.

Free residual chlorination is effective in taste and odor control, in maintaining clean sand and gravel in the filters and in improving coagulation. The advantages which have been derived from its use at the Indianapolis filtration plants considerably outweigh the rather minor problem of control.

Relation of Plankton to Hydrographic Conditions in Sweetwater Lake

By Martin W. Johnson

A paper presented on Oct. 28, 1948, at the California Section Meeting, Riverside, Calif., by Martin W. Johnson, Assoc. Prof. of Marine Biology, Scripps Institution of Oceanography, Univ. of California, La Jolla, Calif.*

THE biology of Southern California lakes is practically an untouched field, although the physical aspects have received some attention, and were the subject in 1941 of a hydrographic report by McEwen (1). In that report the temperature cycle and related changes in the hydrogen ion distribution were considered, and the need for extensive research, including the investigation of the biological phenomena of local lakes was stressed. One of these lakes—Sweetwater—was the subject of a special investigation from June 1944 to June 1945 by members of the University of California Div. of War Research. In this investigation the diurnal and seasonal thermal structure was studied and certain aspects of the biology were included for June, July, August and November.

Sweetwater Lake is a narrow artificial body of water produced as a result of damming the Sweetwater River. About 2 miles long, it runs in a general east-west direction and is located approximately 10 miles inland, where it is exposed to the sea breezes so important to its dynamics.

Hydrography

Part of the hydrographic results of the University of California study were presented by Holtsmark and Gould (2). In Fig. 1, taken from that report, is shown the annual variation from morning to afternoon in the average depth to the top of the thermocline. From this it is seen that a considerable rise may occur daily during the summer and autumn months even though a strong stratification has developed due to a marked temperature gradient (as much as 6°–8° F. per foot) in the thermocline. These diurnal movements of the thermocline are associated with the type of alternating water circulation that has been induced by winds which in summer blow alternately from east to west and west to east. The surface currents of the lake have been measured, and from these and the temperature structure the summer subsurface currents have been deduced, as shown in Fig. 2 redrawn from La Fond (3).

During the summer there is a freshening of westerly winds in late morning. These increase during early afternoon and finally become calm about sundown. The marked thermal stratification which has developed through surface heating resists effective deep circulation and results in the well known summer stagnation common to many deep lakes. In Sweetwater Lake this stagnation reaches a maximum during August and in 1944 was con-

* Scripps Institution of Oceanography, New Series No. 414.

fined to depths below approximately 20 ft. According to computations by McEwen (1), a wind of 30 mph. or more would be required to supply sufficient force to overturn completely or mix the waters during the period from May to October. In contrast, however, a good circulation is maintained in the epilimnion which lies above the thermocline. This is shown by the temperature structure, the well oxygenated condition of the water and the shifting of plankton populations as indicated by collections at the fixed station where observations were made.

It is instructive to consider how the floating life of the lake is affected by these physical conditions and to see

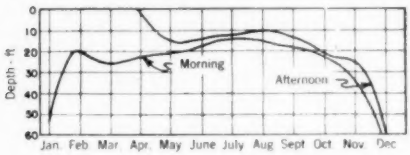

FIG. 1. Average Depth to Top of Thermocline

how the biological, physical and chemical studies are mutually useful in providing an integrated picture of the orderly dynamics involved in the lake environment.

Biological Observations

The plankton collections and the accompanying temperature, turbidity and oxygen observations were made at a barge anchored in the deep water a short distance from the dam. Samples of plankton were collected at frequent depth intervals from the surface to near the bottom. The collections were more closely spaced near the thermocline, since the greatest populations were always found there and the lower limits of stratification of the population were most pronounced. An electrically driven pump which delivered 100 l. of water in four minutes was used for collecting the plankton. In order to confine the water intake to a stratum as narrow as possible, two 1-ft. lengths of $\frac{3}{4}$-in. pipe were connected with a tee, which in turn was attached to the lower end of a 50-ft. garden hose. The water delivered by the pump was filtered through a plankton net of No. 25 silk bolting cloth having mesh apertures of 0.064 mm. Temperatures were taken with a bathythermograph, water samples for oxygen determinations were collected with

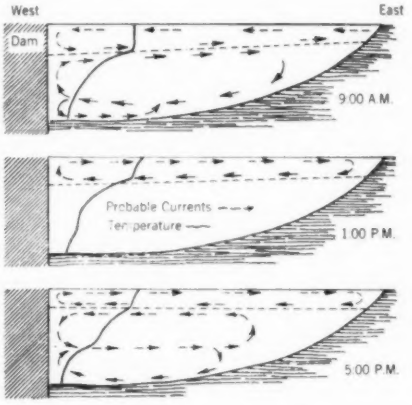

FIG. 2. Probable Currents and Temperature Structure

a Nansen hydrographic bottle and turbidity measurements were made with a photometer giving readings in units of microvolts. The larger the meter reading, the greater is the illumination on the photocell, and consequently a greater transparency is indicated. No absolute values can be assigned to the numbers, but they are comparable for any one set of observations on turbidity and are corrected for solar radiation.

June 20 observations. The earliest biological observations were made in June. At this time two well defined

thermoclines were present at 12 and 32 ft., respectively. The diatom *Fragilaria* was essentially the only photosynthetic organism in the plankton and had its maximum numbers between the two thermoclines (Fig. 3). Copepods, mites, and cladocera were most abundant from 20 to 30 ft. Rotifers were present mainly in and above the upper thermocline and were numerically the most abundant organisms caught.

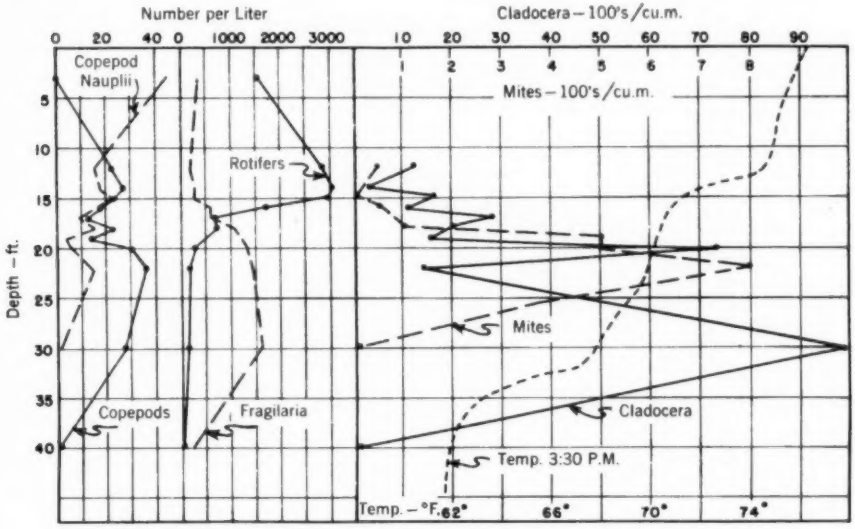

FIG. 3. Vertical Distribution of Plankton and Temperature (June 20)

The total plankton volume was small, but vertically there was a slight increase in the region of the thermocline and a second larger increase between the two thermoclines (Fig. 4). It is significant to note that in June the decline in the major population occurred at depths greater than 30 ft., indicating that living conditions at this time were tolerable at depths from 10 to 15 ft. greater than a month later (Fig. 5–8).

From the turbidity measurements it can be seen that there was a small increase in turbidity just above and within the upper thermocline. Below this level there was a gradual increase in this factor corresponding roughly to an increase in plankton volume. The most turbid water, however, was found at 33 ft., just within the lower thermocline, from which no plankton sample was available. The most transparent water occurred at 39 ft., a depth which lies in the bottom layer with uniform temperature.

July 20 observations. The thermocline fluctuated at a depth near 20 ft. On this date *Fragilaria* was still important among the plants, but *Ceratium* was the dominant form (Fig. 5). *Staurastrum, Pediastrum* and *Cosmarium* were common. All of the plants showed a strong maximum just above or within the thermocline. The zooplankton, shown in Fig. 6 and 7, was strongly stratified with several maxima between depths of 12 and 22 ft. Above 12 ft. only a meager population was found, and below 24 ft. the water was

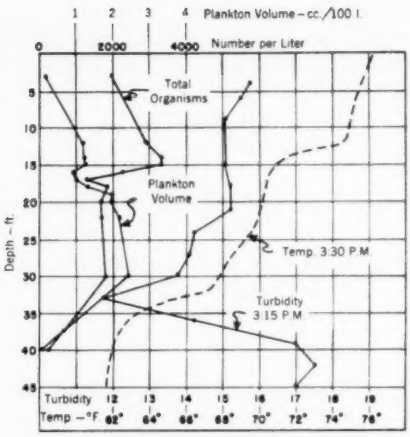

FIG. 4. Total Plankton, Turbidity and Temperature (June 20)

thermocline was between 22 and 26 ft., depending upon the time of day. *Ceratium* was still the principal unicellular photosynthetic organism but reached a maximum of only 4,200 per liter (Fig. 9). The blue-green alga, *Anabaena*, was common from 6 to 19 ft., and *Oscillatoria*, from 32 to 45 ft. Copepods and rotifers were the principal animals (Fig. 10 and 11). As in the July observations, the plankton was confined almost entirely to the water above the thermocline; below 24 ft. little other than *Oscillatoria*, and empty tests of *Ceratium* and rotifers, were noted.

The oxygen profile for this date

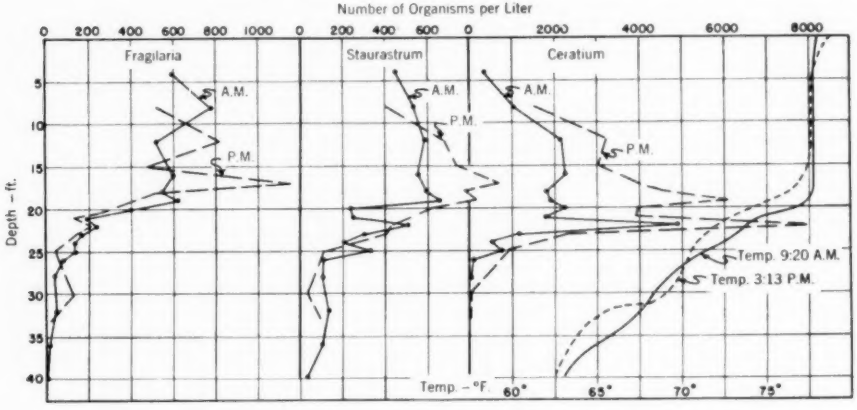

FIG. 5. Phytoplankton and Temperature (July 20)

almost completely sterile of animal life. In Fig. 8 the volume of total plankton indicates a close correlation with the transparency of the water at various depths. Compared with the June observations, however, the greatest turbidity was now at 23 ft., a rise of 10 ft. during the past month.

August 28 observations. The series of observations on this date are of greater interest in that the period of maximum stratification and stability appears to have been reached. The showed a well aerated mixed layer above the thermocline with a small maximum at 20 ft., apparently resulting from the photosynthetic activity of *Ceratium* at or near that depth. Below 20 ft. there was a marked drop in the oxygen, which reached zero in the stratum from 45 ft. to the bottom.

Turbidity varied greatly, with a maximum at or just below the maximum population densities, but with a thick stratum of relatively turbid water well below the population density

The cause of this condition is not evident from an examination of the samples collected, but it may be associated with *Oscillatoria,* which was common from 32 to 45 ft., or with an accumulation of very finely divided detrital material resulting from bacterial breakdown of the plankton above and with fecal detritus from the zooplankton. This fine detrital material might readily pass through the net, thus leaving little evidence of its existence. It will be noted also in Fig. 8 that turbid water had a tendency to occur slightly below the corresponding plankton strata.

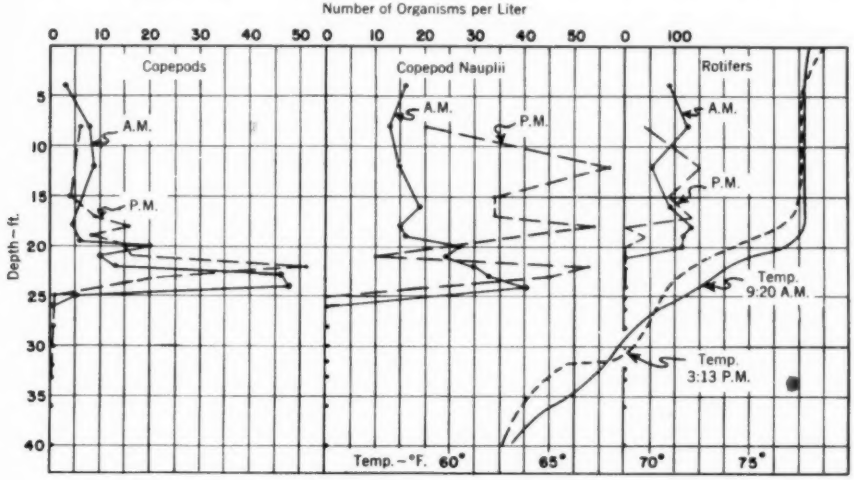

FIG. 6. Zooplankton and Temperature (July 20)

November 20 observations. A complete autumnal overturn had occurred before this date, as witnessed by uniform temperature from top to bottom, nearly uniform oxygen, transparency and a series of alternating strata of plankton from the surface to the bottom (Fig. 12). The principal phytoplankton consisted of a diatom of undetermined genus, together with *Stephanodiscus, Pediastrum,* a very few *Fragilaria* and *Ceratium.* Copepods were the most important of the larger animals and tintinnids were relatively abundant. The total plankton volume was, however, very small.

Discussion

The unpleasant tastes and odors that sometimes occur in drinking water are often associated with concentrations of certain types of microscopic floating life. It is of considerable practical interest, therefore, to learn the biology of the organisms involved and to know their relation to the hydrographic and chemical conditions of the lake. Doubtless each lake presents special problems which are in reality only variations from a general biological and hydrographic cycle common to lakes in this latitude.

The vertical position and fluctuations in the heaviest concentration of planktonic life must be items of considerable importance in determining the level from which water should be drawn from a reservoir for domestic use. The studies on Sweetwater Lake indicate that, as far as the plankton

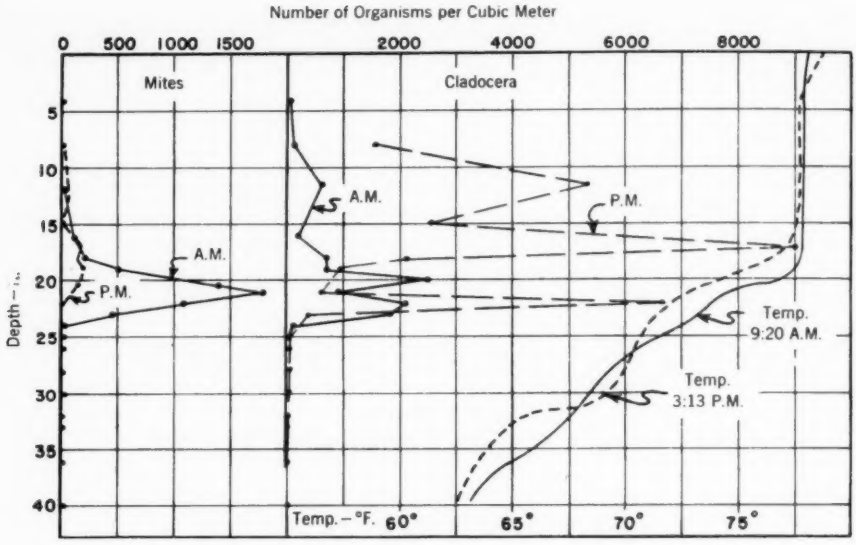

FIG. 7. Zooplankton and Temperature (July 27)

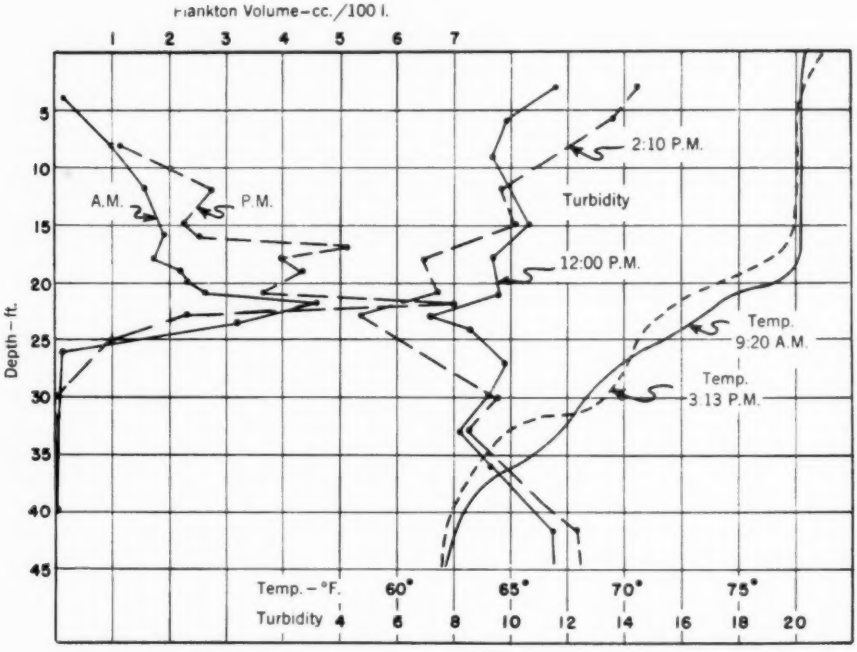

FIG. 8. Total Plankton, Turbidity and Temperature (July 20)

distribution of that lake was concerned during the summer of 1944, the best level from which to draw water would be relatively near the surface, and for depths of 10 to 25 ft. the clearest water would be obtained in the morning.

The observations for July and August are of special interest in showing how the maximum depth and abundance of the plankton at the sampling station situated just above the dam—and, therefore, near the intake—are correlated with the diurnal shift in depth of the thermocline and the direction of flow of the water.

In July the vertical shift is especially clear for the copepods, rotifers and mites (Fig. 6 and 7). The upward shift of these animals is approximately 2 ft., which corresponds with the upward shift of the top of the thermocline between 9:20 A.M. and 3:13 P.M. There was also an afternoon increase in numbers of most organisms, and turbidity was likewise somewhat greater in the afternoon.

The progressive upward shift of the plankton population with the advance of the day is especially well marked in the August 28 observations. On this day the rise was approximately 4 to 5 ft. and agrees with the observed rise in the thermocline during the period. The change in population density, especially of the copepod nauplii (Fig. 10), and of *Ceratium* (Fig. 9) during the seven-hour period on August 28 is further evidence that a lateral shift of population had also occurred.

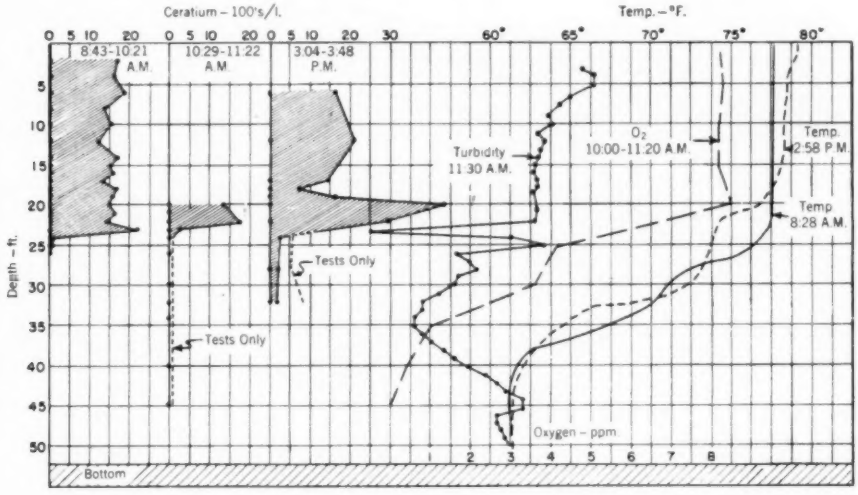

FIG. 9. *Ceratium*, Turbidity, Oxygen and Temperature (Aug. 28)

These diurnal fluctuations in plankton concentration appear to be indicative of a diurnal reversal in the direction of flow of the surface water and of a compensatory flow in the subsurface water at the thermocline, as already deduced from the hydrographic study. We have seen that the organisms reach a maximum concentration at subsurface depths, there being relatively few near the surface. During periods of easterly winds this plankton-poor water flows westward toward

the dam, where it is diverted downward, replacing the plankton-rich water which now flows eastward with its population along the thermocline. When the water currents are reversed, following an increase of westerly winds during the day (*see* Fig. 2), the plankton-rich water again flows into the area near the dam. Thus, the morning samples are relatively poor in plankton compared to those collected at the same station in the afternoon. The complicating effects of vertical diurnal migration of certain animals were not studied.

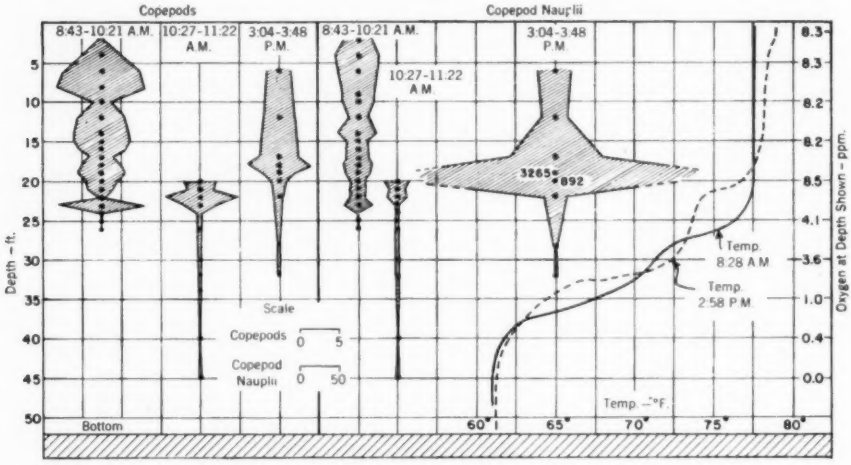

FIG. 10. Copepods, Temperature and Oxygen (Aug. 28)

The autumnal overturn is an event of prime importance to the biology of Sweetwater Lake, as in other similar lakes. During the summer period of strong thermal stratification there is a continual consumption of the mineral plant nutrients (nitrates and phosphates) by floating plants in the upper water layers. Gradually these nutrients are bound as organic substance in the bodies of the plants, or of animals feeding upon the plants, and hence must be largely precipitated into the deeper water as dead bodies or fecal detritus. On the bottom the organic material is again reduced to the mineral state through bacterial action. Because of the lack of deep circulation at this time, the oxygen of the deep water becomes more or less exhausted, carbon dioxide increases and hydrogen sulfide may develop. The nutrients regenerated at the bottom remain unused by the plants, either because of toxic substances or lack of sufficient light at that depth. Initially the lack of light is probably the cause, though the compensation depth (the depth where the oxygen production by photosynthesis and the oxygen consumption by respiration of the plants is equal) has not been determined for this lake at any season. Despite this withdrawal of nutrients from the surface to the bottom, there may still be a notable production of organic material in the surface waters.

In a report on the phosphorus cycle in a lake, Hutchinson and Bowen (4) have reviewed literature showing that there may be a series of flares of phytoplankton growth without a reduction of the phosphate content in the surface

waters, or on occasions the phosphate and plankton might increase simultaneously, even in stratified lakes. Hence, it is believed that the low phosphorus concentrations in surface waters during the summer should be regarded as a steady condition which represents a more or less balanced state between phosphorus replenishment and its consumption by plants. Since there is a constant withdrawal of phosphorus, in the form of sinking particulate material, into the temporary summer storehouse below the thermocline, where it was apparently out of circulation with the surface layer. The total phosphorus in the layer above the thermocline had, however, increased during the week, and it was believed that this increase was due to horizontal transport from the shallower portion of the lake with depths above the thermocline. Regenerated nutrients might therefore constantly become available from the muds in such areas, which amounted to 24.6 per cent of the lake bottom in the lake studied.

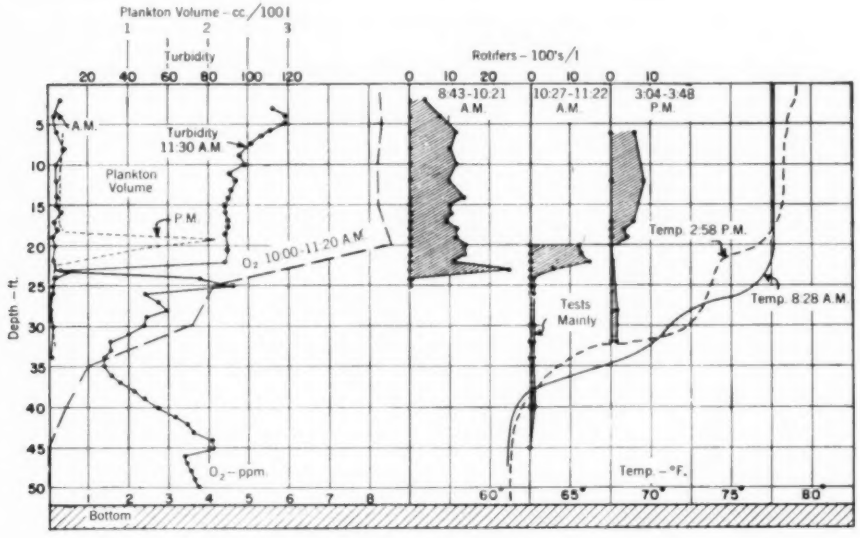

FIG. 11. Total Plankton and Rotifers (Aug. 28)

cline, a question arises as to the origin of this slow summer replenishment of nutrients above the thermocline.

In an attempt to follow the cycle directly, Hutchinson and Bowen (4) used the radioactive isotope of phosphorus P^{32}. They liberated a quantity of radiophosphorus along sections across a small lake and after a week's time made tests which indicated a downward movement of 57 per cent of the phosphorus into and below the

A recent review (5) of the literature dealing with the bacterial regeneration of plant nutrients presents considerable evidence that phosphates and ammonia nitrogen are rapidly liberated from diatom and copepod plankton. In lakes, doubtless, some regeneration of nutrients takes place in the free water above the thermocline, since it is known that a large bacterial population commonly exists together with the main plankton population (6). Moreover, it

has been shown by several workers that the nitrogen assimilated by some plants, including diatoms, may be obtained from ammonia (NH_3) or, to some extent, even from the amino acids. Thus, it is not necessary to go through the slower formation of nitrite (NO_2) or nitrate (NO_3) before the nitrogen becomes available to the phytoplankton. This process would supplement the nitrogen that must also be liberated together with the phosphorus from muds in the littoral area.

Acknowledgment

Most of the work forming the basis of this report was done while the author was a member of the staff of the University of California Div. of War Research at the U.S. Navy Radio and Sound Laboratory (now the U.S. Navy Electronics Laboratory), San Diego, Calif. Various members of the Oceanographic Section assisted in the study. J. H. Martin, in charge of the calibration barge at the lake, assisted especially with the turbidity measurements.

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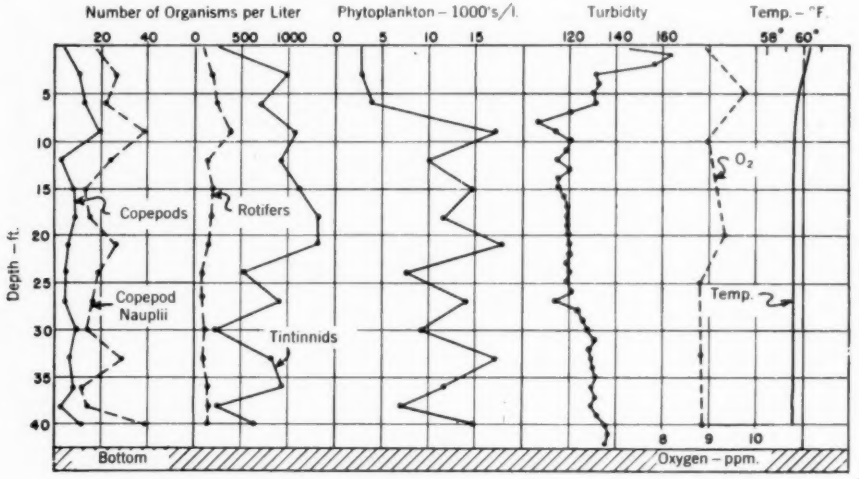

Fig. 12. Uniform Conditions Resulting From Lake "Overturn"

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Standard Specifications

for

ELEVATED STEEL WATER TANKS, STANDPIPES AND RESERVOIRS

American Water Works Association
American Welding Society
New England Water Works Association

These "Standard Specifications for Elevated Steel Water Tanks, Standpipes and Reservoirs" are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and the advisability of use of the material herein specified for any installation must be subjected to review by the engineer responsible for the construction in the particular locality concerned.

Approved as Revised, by the Board of Directors of the A.W.W.A., September 20, 1948; by the Board of Directors of the American Welding Society, October 25, 1948; and by the New England Water Works Association, September 14, 1948.

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Eleventh Printing, April 1949

AMERICAN WATER WORKS ASSOCIATION
Incorporated
500 Fifth Avenue, New York 18, N.Y.

Foreword

These specifications were prepared by a joint committee of the American Water Works Association and the American Welding Society consisting of L. R. Howson, General Chairman, H. O. Hill, H. A. Sweet, Bryan Blackburn, J. P. Schwada, J. O. Jackson, H. C. Boardman and N. T. Veatch Jr.

These specifications are a revision and extension to include welded construction of the specifications entitled "Standard Specifications for Riveted Steel Elevated Tanks and Standpipes" which were prepared by Subcommittee 7H of the American Water Works Association and published tentatively in the JOURNAL in December, 1931, and finally in the JOURNAL, November, 1935. Those specifications covered riveted construction only. The purpose of the present specifications is to provide a uniform guide for minimum requirements as to the design, fabrication and erection of elevated steel water tank, standpipe and reservoir structures of either welded or riveted construction.

All requirements relative to welding in these specifications have been taken from American Welding Society "Rules for Field Welding of Steel Storage Tanks."

These specifications were approved as "Tentative Standard" by the Executive Committee of the American Welding Society on April 4, 1940; and by the Board of Directors of the American Water Works Association on April 25, 1940. These specifications were approved as "Standard" by the Board of Directors of the American Water Works Association on June 26, 1941; by the Executive Committee of the American Welding Society on July 23, 1941; and by the New England Water Works Association on September 24, 1942. The latest revisions of these specifications were approved by the Board of Directors of the American Water Works Association on September 20, 1948; by the Board of Directors of the American Welding Society on October 25, 1948; and by the New England Water Works Association on September 14, 1948.

These specifications were originally published as a part of the December 1940 JOURNAL, and first revised in the December 1942 JOURNAL.

Table of Contents

Foreword ..... Page 358

SECTION

General—Section 1

Local Requirements 1.1
Definitions 1.2
What the Purchaser Is to Furnish ... 1.3
What the Contractor Is to Furnish .. 1.4
Information to Be Furnished by Purchaser 1.5
Information to Be Furnished by Bidder 1.6
Guarantee 1.7

Materials—Section 2

Bolts, Anchor Bolts and Threaded Rods 2.1
Reinforcing Steel 2.2
Plates 2.3
Basis of Furnishing Plates 2.4
Structural Shapes 2.5
Copper Bearing Steel 2.6
Rivets 2.7
Pins 2.8
Castings 2.9
Forgings 2.10
Filler Metal 2.11

General Design—Section 3

Type of Joints 3.1
Design Loads 3.2
Unit Stresses 3.3
Combined Stresses 3.4
Column and Strut Formulas 3.5
Slenderness Ratio 3.6
Roofs and Top Girders 3.7
Roof Supports 3.8
Foundation Bolts 3.9
Corrosion Allowance 3.10
Minimum Thickness 3.11
Joints in Shell Plates 3.12
Riveted Joint Design 3.13
Riveted Joint Efficiency 3.14
Weld Design Values—Structural Joints 3.15
Weld Design Values—Tank Plate Joints 3.16
Reinforcement Around Openings 3.17

Design of Standpipes and Reservoirs—Section 4

Standard Capacities 4.1
Standard Shell Height for Standpipes. 4.2
Standard Diameters for Reservoirs .. 4.3

Design of Elevated Tanks—Section 5

Standard Capacities 5.1
Standard Heights for Elevated Tanks. 5.2
Standard Ranges of Head 5.3
Columns and Struts 5.4
Column Splices 5.5
Bottom Struts 5.6
Tension Members Carrying Wind and/or Earthquake Loads 5.7
Horizontal Girders 5.8
Balcony Railing 5.9
Tank Plates 5.10
Steel Riser Pipe 5.11

Accessories for Standpipes and Reservoirs—Section 6

Shell Manhole 6.1
Pipe Connection 6.2
Overflow 6.3
Outside Tank Ladder 6.4
Roof Ladder 6.5
Roof Hatch 6.6
Vent 6.7
Additional Accessories 6.8

Accessories for Elevated Tanks—Section 7

Tower Ladder 7.1
Outside Tank Ladder 7.2
Roof Hatch 7.3
Roof Finial 7.4
Roof Ladder 7.5
Vent 7.6
Steel Riser Pipe 7.7
Pipe Connection 7.8
Overflow 7.9
Additional Accessories 7.10

Welding—Section 8

Definitions and Symbols 8.1
Qualification of Welding Procedures and Welding Operators 8.2
Butt Joints Subject to Primary Stress Due to Weight or Pressure of Tank Contents 8.3
Butt Joints Subject to Secondary Stress 8.4
Lap Joints Subject to Primary Stress Due to Weight or Pressure of Tank Contents 8.5
Lap Joints Subject to Secondary Stress 8.6
Flat Tank Bottoms Resting Directly on Grade or Foundation 8.7
Shell to Bottom Joint (Applies to Vertical Cylindrical Shells With Flat Bottoms) 8.8
Roof Plates 8.9
Maximum Thickness of Material to Be Welded 8.10
Minimum Laps for Lap Joints 8.11

	SECTION
Intermittent Welding	8.12
Minimum Size of Fillet and Seal Welds	8.13
Minimum Length of Welds	8.14

Shop Fabrication—Section 9

Workmanship	9.1
Straightening	9.2
Laying Out	9.3
Rivet Holes	9.4
Plate Edges—Riveted Work	9.5
Finish of Plate Edges—Welded Work	9.6
Scarfing for Riveted Construction	9.7
Rolling	9.8
Double Curved Plates	9.9
Milling Columns	9.10
Shop Assembly	9.11
Shipping	9.12

Erection—Section 10

General	10.1
Riveted Tanks	10.2
Welded Tanks	10.3
Welds—General	10.4
Preparation of Surfaces to Be Welded	10.5
Weather Conditions	10.6
Preheating and Interpass Temperature	10.7
Cleaning Between Passes	10.8
Tack Welds	10.9
Peening	10.10
Weld Contour	10.11
Weld Reinforcement	10.12
Chipping and Gas-Gouging of Welds	10.13
Flat Tank Bottoms	10.14
Tank Shell	10.15
Matching Plates	10.16
Grouting Column and Riser Bases	10.17
Sand Cushion	10.18
Cleaning Up	10.19

Inspection—Section 11

Riveted or Welded Tanks	11.1
Field Inspection	11.2
Application	11.3
Sectional Specimens	11.4
Number and Location of Test Segments	11.5
Size of Sectional Segments	11.6
Preparation of Sectional Segments	11.7
Inspection of Sectional Segments	11.8
Method of Closing Openings	11.9
Record of Segments	11.10
When Inspected	11.11
Who Pays for the Field Inspection	11.12

Testing—Section 12

Riveted Flat Bottoms	12.1
Welded Flat Bottoms	12.2
General	12.3
Disposal of Test Water	12.4

Field Painting—Section 13

General	13.1
Workmanship	13.2
Painting	13.3
Aluminum Paint	13.4

Appendix

General	A1
Information to Be Furnished by Purchaser for an Elevated Tank	A2
Information to Be Furnished by Purchaser for a Standpipe or Reservoir	A3
Information to Be Furnished by Bidder for an Elevated Tank	A4
Information to Be Furnished by Bidder for a Standpipe or Reservoir	A5
Drawings	A6
Cleaning and Shop Painting	A7
Field Painting	A8
Kind of Paint	A9
Types and Kinds of Paint	A10
Electric Cathodic Protection of Tank Interiors	A11
Foundations—General	A12
By Whom Designed	A13
Soil Bearing Value	A14
Riser Foundations	A15
Column Foundations	A16
Concrete Design and Materials	A17
Detail Design of Foundations	A18
Size of Top	A19
Pouring	A20
Finish	A21
Design of Foundations Without Reinforcement	A22

NOTE: Several of the references to A.S.T.M. Specifications in Section 2 were changed, effective July 1947, to accord with new A.S.T.M. designations.

Standard Specifications for Elevated Steel Water Tanks, Standpipes and Reservoirs

Section 1—General

1.1. *Local Requirements:* Where local, municipal, county, state or government requirements exist such requirements are to govern and these specifications shall be interpreted to supplement them.

1.2. *Definitions:* Under these specifications the following definitions will apply:

Elevated Tank shall mean a container or storage tank supported on a tower.

Standpipe shall mean a flat bottom cylindrical tank having a shell height greater than its diameter.

Reservoir shall mean a flat bottom cylindrical tank having a shell height equal to or smaller than the tank diameter.

Tank shall mean an elevated tank, a standpipe or a reservoir.

Purchaser shall mean the person, company or organization which purchases the tank.

Engineer shall refer to the purchaser's engineer.

Contractor shall mean the person or company who contracts with the purchaser under these specifications to furnish and erect the tank.

Capacity shall mean that contained between the level of the overflow and the lowest specified level.

1.3. *What the Purchaser Is to Furnish:* The purchaser shall furnish the site upon which the tank is to be built with sufficient space to permit the contractor to erect the structure using customary methods. The purchaser shall furnish foundations. Unless otherwise agreed the purchaser shall furnish at the tank site the water at the proper pressure for testing and facilities for disposing of waste water, after testing. The purchaser shall furnish a suitable right of way from the nearest public road to the erection site.

1.4. *What the Contractor Is to Furnish:* The contractor shall furnish foundation plans, the anchor bolts, all materials except for foundations, all labor necessary to complete the structure including the accessories required by these specifications and any additional work or accessories separately specified by the purchaser.

1.5. *Information to Be Furnished by Purchaser:* In his advertisement or inquiry the purchaser shall furnish the information itemized in Sec. A2 for elevated tanks or that in Sec. A3 for standpipes or reservoirs.

1.6. *Information to Be Furnished by Bidder:* Each bidder shall furnish the information itemized in Sec. A4 for elevated tanks or that in Sec. A5 for standpipes or reservoirs.

1.7. *Guarantee:* The contractor shall guarantee the structure against any defective materials or workmanship including paint and painting if in accordance with Sec. A8, A9, and A10 for a period of one year from date of completion. If any materials or workmanship prove to be defective within one year they shall be replaced or repaired by the contractor.

Section 2—Materials

2.1. *Bolts, Anchor Bolts and Threaded Rods:* Bolts, anchor bolts and threaded rods shall conform to any of the following A.S.T.M. specifications of the latest revision: A 7, Specifications for Steel for Bridges and Buildings (Bolting Materials); A 141, Specifications for Structural Rivet Steel; A 31, Specifications for Boiler Rivet Steel and Rivets; or A 107, Hot-Rolled Carbon Steel Bars, Grades 1008, 1010 and 1015.

2.2. *Reinforcing Steel:* Reinforcing steel shall comply with the latest revision of A.S.T.M. Specifications A 15 (structural or intermediate grade).

2.3. *Plates:* Plate materials shall be open-hearth steel conforming to any of the following A.S.T.M. specifications of the latest revision: A 7, Specifications for Steel for Bridges and Buildings; A 283, Grades A, B, C and D—Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality; A 285, Grades A, B and C—Specifications for Low and Intermediate Tensile Strength Carbon Steel Plates of Flange and Fire-Box Qualities; or A 113, Specifications for Structural Steel for Locomotives and Cars (plates for cold pressing).

2.4. *Basis of Furnishing Plates:* Plates in the tank shell and suspended bottom shall not underrun the required thickness, based upon the specified unit stress, by more than 0.01 in. All other plates may be furnished on the weight basis with permissible underrun and overrun according to the tolerance table for plates ordered to weight published in the applicable A.S.T.M. specification.

2.5. *Structural Shapes:* Structural materials shall be open-hearth steel conforming to either of the following A.S.T.M. specifications of the latest revision: A 7, Specifications for Steel for Bridges and Buildings; or A 113, Specifications for Structural Steel for Locomotives and Cars (structural steel for locomotives).

2.6. *Copper Bearing Steel:* Copper bearing steel with content of about 0.20 per cent copper may be used when specified. In other particulars the steel shall conform to specifications enumerated above.

2.7. *Rivets:* Rivets shall comply with the latest revision of A.S.T.M. Specifications A 31 or A 141. If cold driving is done, properly annealed rivets conforming to A.S.T.M. Specifications A 31 should be used.

2.8. *Pins:* Pins shall comply with A.S.T.M. specifications A 7 (Bolting Material) or A 108 Grade 1025 of the latest revision.

2.9. *Castings:* Castings shall conform to the latest revision of A.S.T.M. specification A 27, Grade 60–30, Specifications for Medium-Strength Steel Castings for General Application.

2.10. *Forgings:* Forgings shall conform to one of the following A.S.T.M. specifications of the latest revision:

2.10.1. *Plate Forgings:* A 283, Grades A, B, C and D—Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality (plates 2 in. and under in thickness); A 285, Grades A, B and C—Specifications for Low and Intermediate Tensile Strength Carbon Steel Plates of Flange and Fire-box Qualities (plates 2 in. and under in thickness).

2.10.2. *Forgings, Other than Plate:* A 235, Class B, Specifications for Carbon-Steel Forgings for General Industrial Use.

2.10.3. *Forged and Rolled Pipe Flanges:* A 181, Grade I, Specifications

for Forged or Rolled Steel Pipe Flanges for General Service.

2.11. *Filler Metal:* The specifications cited below shall be followed for filler metal:

2.11.1. *Electrodes:* All arc-welding electrodes shall conform to the requirements of the A.W.S.—A.S.T.M. Specifications for Iron and Steel Arc-Welding Electrodes (A.W.S. designation A 5.1; A.S.T.M. designation A 233) of the latest revision. Electrodes shall be of classifications E 6010, E 6011, E 6012, E 6013, E 6020 and E 6030, and shall be suitable for the positions of welding and other conditions of intended use.

2.11.2. *Gas-Welding Rods:* All gas-welding rods shall conform to the requirements of the A.W.S.—A.S.T.M. Specifications for Iron and Steel Gas-Welding Rods (A.W.S. designation A 5.2, A.S.T.M. designation A 251) of the latest revision. Welding rods shall be of classification GA–60 and shall be suitable for the conditions of intended use.

Section 3—General Design

3.1. *Type of Joints:* Unless specifically restricted by the purchaser, joints and connections in structures built under these specifications may be either riveted or welded or parts may be riveted or welded at the option of the contractor.

Lap welded joints between plates in contact with tank contents except bottom plates supported directly on grade or foundation shall be welded continuously on both edges.

3.2. *Design Loads:* The following loads shall be considered in the design of tank structures:

3.2.1. *Dead load* shall be the estimated weight of all permanent construction and fittings. The unit weight of steel shall be considered 490 lb. per cu.ft. and of concrete 144 lb. per cu.ft.

3.2.2. *Live load* shall be the weight of all of the liquid when the tank is filled to overflowing. Unit weight of water shall be considered as 62.4 lb. per cu.ft. The weight of any water, supported directly on foundations, shall not be considered as a live load on the superstructure.

3.2.3. *Snow load* shall be 25 lb. per sq.ft. of the horizontal projection of the tank for surfaces having a slope of less than 30 deg. with the horizontal. For greater roof slope snow loads shall be neglected.

3.2.4. *Wind load* or pressure shall be assumed to be 30 lb. on vertical plane surfaces, 18 lb. on projected areas of cylindrical surfaces and 15 lb. per sq.ft. on projected areas of conical and double curved plate surfaces. (It may be desirable to increase the wind loads above by as much as 50 per cent in hurricane areas.)

For columns and struts of structural shapes, the projected area shall be calculated. Struts on the leeward side of the tower shall be assumed as being shielded 50 per cent by those on the windward side. In the case of columns and sway rods, the wind pressure shall be applied on the projected area of each member.

In calculating the wind load on elevated tank structures the entire wind load on the tank, roof and bottom and the proper proportion of the wind load from the riser pipe and tower shall be assumed to act on the tank at the center of gravity of such loads.

3.2.5. *Earthquake Load:* If any provision is to be made in the design

for earthquake resistance the purchaser shall so specify. *Note:* Present practice is to assume a horizontal force of from 5 to 20 per cent of the total weight of the water in the tank and riser acting at the center of mass of the water, the percentage used depending upon the proximity of an earthquake-producing fault and the hazard to surrounding property in the event of an earthquake failure or upon local regulations.

3.2.6. *Balcony and Ladder Load:* A vertical load of 1000 lb. shall be assumed to be applied to any point on the balcony floor, if any, and on each platform; 500 lb. at any point on the tank roof; 350 lb. on each section of ladder; and all of the structural parts and connections shall be properly proportioned to withstand such loads.

3.3. *Unit Stresses:* With the exceptions specifically provided for elsewhere in these specifications, all steel members shall be so designed and proportioned that, during the application of any of the loads previously specified, or any combination of them, the maximum stress shall not exceed the following:

	Maximum Fiber Stress psi.
3.3.1. *Tension:*	
Structural steel	15,000
Rivets, on area based on nominal diameter	11,250
Bolts, on area based on diameter at root of threads	11,250
Cast steel	11,250
Steel Plates in tank shells (see exceptions in Sec. 5.10).	15,000
3.3.2. *Compression:*	
Structural steel and weld metal	15,000
Columns and struts	*See* Sec. 3.5
Plate girder stiffeners	15,000
Webs of rolled sections at toe of fillet	18,000
Cast steel	15,000
3.3.3. *Bending:*	
Tension on extreme fibers, except column base plates	15,000
Column base plates	20,000
Compression on extreme fibers of rolled sections, and built-up girders and built-up members, for values of $\frac{l}{b}$ not greater than 40, where l is laterally unsupported length of the member and b is the width of the compression flange	$\frac{16{,}875}{1 + \frac{l^2}{1{,}800b^2}}$ with a maximum of 15,000
Pins, extreme fiber	22,500
Cast steel	11,250
3.3.4. *Shearing:*	
Rivets	11,250
Pins and turned bolts in reamed or drilled holes	11,250
Unfinished bolts	7,500
Webs of beams and plate girders, gross section	9,750
Cast steel	7,325

3.3.5. *Bearing:*

	Double Shear	*Single Shear*
Rivets	30,000	24,000
Turned bolts in reamed or drilled holes	30,000	24,000
Unfinished bolts	18,750	15,000
Pins	24,000	
Contact area of milled surfaces	22,500	
Contact area of fitted stiffeners	20,250	
Expansion rollers and rockers (pounds per linear inch) where d is the diameter of roller or rocker in inches		$600d$
Concrete (see Sec. A22)		
2,000 lb. Concrete		500
2,500 lb. Concrete		625
3,000 lb. Concrete		750

Unit stress values wherever stated in these specifications shall be reduced by multiplying them by the applicable joint efficiencies.

3.4. *Combined Stresses:*

3.4.1. *Axial and Bending:* Members subjected to both axial and bending stresses shall be so proportioned that the quantity $\frac{fa}{Fa} + \frac{fb}{Fb}$ shall not exceed unity, in which:

Fa is the axial unit stress that would be permitted by this specification if axial stress only existed.

Fb is the bending unit stress that would be permitted by this specification if bending stress only existed.

fa is the axial unit stress (actual) = axial stress divided by area of member.

fb is the bending unit stress (actual) = bending moment divided by section modulus of member.

3.4.2. *Rivets:* Rivets subject to shearing and tensile forces shall be so proportioned that the combined unit stress will not exceed the allowable unit stress for rivets in tension only.

3.4.3. *Wind and Other Forces:* Members including foundations subject to stresses produced by a combination of wind and/or earthquake and other loads may be proportioned for unit stresses 25 per cent greater than those specified in Sec. 3.3 and 3.5, provided the section thus required is not less than that required for the combination of dead load and live load. It is not necessary to combine wind stress and earthquake stress, but to proportion each member for the larger of the two in combination with stresses produced by other causes.

Members subject only to stresses produced by wind forces and/or earthquake forces may be proportioned for unit stresses 25 per cent greater than those specified in Sec. 3.3 and 3.5.

3.5. *Column and Strut Formulas:* The following formulas shall be applied:

3.5.1. *Structural Sections:* The maximum permissible unit stress for structural columns or struts shall be determined from the following formula:

$$\frac{P}{A} = \left[\frac{18000}{1 + \frac{L^2}{18000r^2}} \right]$$

or 15,000 psi., whichever is smaller.

3.5.2. *Tubular Sections:* The maximum permissible stress for tubular columns and struts shall be determined by the formula:

$$\frac{P}{A} = XY,$$

in which:

$$X = \frac{18000}{1 + \frac{L^2}{18000r^2}}$$

or 15,000 psi., whichever is the smaller, and

$$Y = \left(\frac{2}{3}\right)\left(100\,\frac{t}{R}\right)\left[2 - \left(\frac{2}{3}\right)\left(100\,\frac{t}{R}\right)\right]$$

or unity (1.00), whichever is the smaller.

In the foregoing formulas, the symbols have the following meaning:

P = the total axial load in pounds.
A = the cross-sectional area in square inches.
L = the effective length in inches.
r = the least radius of gyration in inches.
R = the radius of the tubular member to the exterior surface in inches.
t = the thickness of the tubular member in inches; minimum allowable thickness $\frac{1}{4}$ in.

All circumferential joints in tubular sections shall be butt joints either welded for complete penetration or riveted with butt straps on both sides.

3.6. *Slenderness Ratio:* The maximum permissible slenderness ratio $\left(\frac{L}{r}\right)$ for compression members carrying weight or pressure of tank contents shall be 120.

The maximum permissible slenderness ratio $\left(\frac{L}{r}\right)$ for compression members carrying loads from wind and/or earthquake only shall be 175.

The maximum permissible slenderness ratio $\left(\frac{L}{r}\right)$ for columns carrying roof loads only shall be 175.

3.7. *Roofs and Top Girders:* All tanks storing drinking water should have roofs. Tanks without roofs shall have a top girder or angle having a minimum section modulus as determined by the following formula:

$$S = \frac{HD^2}{10000}$$

In the above formula S is the minimum required section modulus in inches cubed of the top angle or girder, including a length of tank shell equal to twenty times its thickness; H is the height of the cylindrical portion of the tank shell in feet; and D is the diameter of the cylindrical portion of the tank shell in feet.

3.8. *Roof Supports:* Roof supports, if any, shall be designed in accordance with the current specifications of the American Institute of Steel Construction, except that the ratio $\frac{l}{b}$ of unbraced length to width of flange of rafters in contact with roof sheets shall not be restricted, as it is considered that the roof sheets will provide lateral supports for the rafters, and except that the maximum slenderness ratio $\frac{L}{r}$ for columns supporting roofs shall be 175.

Roof trusses shall be placed above the maximum water level in climates where ice may form.

Roof rafters shall preferably be placed above the maximum water level but it will be permissible for their lower ends, where they connect to the tank shell, to project below the water level.

3.9. *Foundation Bolts:* Foundation bolts may be either plain or deformed bars, either upset or not upset. They shall be proportioned for the maximum possible uplift, using the area at the base of the thread or the un-upset rod diameter, whichever is smaller. Foundation bolts may extend into the pier to within 3 in. from the bottom of the pier, but not necessarily more than far enough to develop the maximum uplift, and shall terminate in a right angle bend, hook or washer plate. The threaded ends of foundation bolts shall extend 2 in. above the nominal level of the tops of the foundation bolt nuts to provide for variations in the foundations. Lock nuts shall be provided or the threaded ends of anchor bolts shall be peened to prevent loosening of anchor nuts.

3.10. *Corrosion Allowance:* Careful consideration shall be given by the purchaser to the proper allowance for corrosion. This allowance will depend upon the corrosive nature of the stored water, the proximity of the tank to salt water or other causes of atmospheric corrosion and the care with which the paint or other protection will be maintained. If corrosion allowance is desired the purchaser shall specify the allowance for parts in contact with water and for parts not in contact with water. The corrosion allowance specified by the purchaser is to be added to the thickness determined from the specified design units and to the minimum thicknesses specified in the following section. In the case of beams and channels, the corrosion allowance need be added to the webs only and not to the flanges.

3.11. *Minimum Thickness:* The minimum thickness for any part of the structure shall be $\frac{3}{16}$ in. for parts not in contact and $\frac{1}{4}$ in. for parts in contact with water contents. The minimum thickness for tubular columns and struts shall be $\frac{1}{4}$ in. Round or square bars used for wind bracing shall have a minimum diameter or width of $\frac{5}{8}$ in. Bars of other shapes, if used, shall have a total area at least equal to a $\frac{5}{8}$ in. round bar.

3.12. *Joints in Shell Plates:* In calculating the thicknesses of plates stressed by the weight or pressure of the tank contents, the pressure at the lower edge of each ring shall be assumed to act undiminished on the entire area of the ring. Joints subjected to stress from weight or pressure of tank contents in adjacent courses shall be staggered.

3.13. *Riveted Joint Design:* The riveted joint design shall comply with current good practice as regards the size of rivets, edge distance for calking and non-calking edges, the angle of bevel of calking edges and the minimum and maximum rivet pitches and back pitches.

The following represents good practice:

The minimum rivet pitch shall be not less than three times the nominal diameter of the rivet.

The maximum pitch along a calked edge where the calking is necessary for water tightness shall be ten times the thickness of the thinnest plate connected.

Maximum pitch along uncalked edges of tank plates shall not exceed 30 times the thickness of the thinnest plate connected.

The distance between the center of the outer row of rivets and the edge of plate shall not be less than 1.5 times the diameter of the rivets. Where edges are beveled, the distance from the center of rivets to the toe of the

bevel shall not exceed 1.75 times the diameter of the rivets.

Spacing between rows of rivets shall be as follows:

3.13.1. For joints where one rivet in the inner row comes midway between two rivets in the outer row, the spacing between the rivets or back-pitch shall be $1.75d + 0.185\ (P - 4d)$, with a minimum of $1.75d$.

3.13.2. For joints where two rivets in the inner row are placed between two rivets in the outer row, the back-pitch shall equal $2d + 0.14\ (P - 4d)$, with a minimum of $2d$.

P is the pitch, in inches, of the rivets in the outer row.

d is the diameter of the rivet holes in inches.

3.14. *Riveted Joint Efficiency:* The joint efficiency for riveted joints shall be calculated on the basis of the previously specified unit stresses.

For punched holes the shear and bearing of rivets shall be based on the nominal rivet diameter and the net tension or tearing shall be based on the nominal rivet diameter plus $\frac{1}{8}$ in.

For drilled or subpunched and reamed holes the shear, bearing and tension or tearing shall be based on the drilled or reamed diameter of the holes.

The joint shall be designed and the efficiency determined before adding the corrosion allowance.

3.15. *Weld Design Values—Structural Joints:* Welded joints shall be proportioned so that the stresses on a section through the throat of the weld, exclusive of weld reinforcement, shall not exceed the following percentages of the allowable working tensile stress of the structural material joined.

3.15.1. *Groove Welds:*

Tension	85 per cent
Compression	100 per cent
Shear	75 per cent

3.15.2. *Fillet Welds:* *

Transverse Shear	65 per cent
Longitudinal Shear	50 per cent

* Stress in a fillet weld shall be considered as shear on the throat, for any direction of the applied load. The throat of a fillet weld shall be assumed as 0.707 times the length of the shorter leg of the fillet weld.

3.16. *Weld Design Values—Tank Plate Joints:*

Type of Joint	*Efficiency, per cent*
3.16.1. Double-welded butt joint with complete penetration.	85 Tension; 100 Compression
3.16.2. Double-welded butt joint with partial penetration and with the unwelded portion located substantially at the middle of the thinner plate.	$85\ \frac{Z}{T}$ Tension; $100\ \frac{Z}{T}$ Compression

Where Z is the total depth of penetration from the surfaces of the plate, (use the thinner plate if of different thicknesses);

T is the thickness of the plate, (use the thinner plate if of different thicknesses).

3.16.3. Single-welded butt joint with suitable backing-strip or equivalent means to insure complete penetration.	85 Tension; 100 Compression

Type of Joint	*Efficiency, per cent*
3.16.4. Double-welded transverse lap joint with continuous full-fillet weld on each edge of joint.	75 Tension or Compression
3.16.5. Double-welded transverse lap joint with continuous full-fillet weld on one edge of joint and an intermittent full-fillet weld on the other edge of joint.	$75\frac{(1+X)}{(2)}$ Tension or Compression

Where X is the ratio of the length of intermittent full-fillet weld to the total length of joint, expressed as a decimal.

3.16.6. Lap joint with transverse full-fillet weld, or smaller, on either or both edges of the joint, welds either continuous or intermittent.	$75\frac{(XW_1+YW_2)}{2T}$ Tension or Compression

Where X and Y are the ratios of the lengths of intermittent welds W_1 and W_2, respectively, to the total length of the joint, expressed as a decimal.

W_1 and W_2 are the sizes of the welds on each edge of the joint respectively.

(W_2 will be zero for a joint welded on one edge only.)

T is the thickness of plate. (use the thinner plate if of different thicknesses).

3.17. *Reinforcement Around Openings:* All openings over 4 in. in diameter in the shell or suspended bottom of the tank shall be reinforced. This reinforcement may be the flange of a fitting used or an additional ring of metal, or both flange and ring.

The amount of reinforcement for a riveted tank shell shall be computed as follows:

3.17.1. In computing the necessary reinforcement of an opening in a tank shell, the net area of the reinforcement shall bear the same ratio to the area of the metal removed from the shell as the strength of the vertical joint in the shell course bears to the strength of the solid plate.

3.17.2. Sufficient rivets shall be used to transmit to the shell plate by shear the full strength of the reinforcing ring or flange, at a maximum unit shear of 75 per cent of unit tensile stress used in designing the shell plate.

The amount of reinforcement for a welded tank shell shall be computed as follows:

3.17.3. The strength of the required reinforcement around an opening in a shell plate shall be based on the vertical cross-sectional area of the metal removed from the plate. This area shall be taken as the product of the vertical diameter of the hole cut in the shell plate and the thickness of the plate (100 per cent reinforcement). The strength through the net cross-sectional area of the reinforcement added, lying in a vertical plane (plane of reinforcement) coincident with the axis of the opening, shall at least equal that of the product referred to above.

3.17.4. The aggregate strength of the welding attaching a fitting to the shell plate and/or any intervening reinforcing plate shall at least equal the proportion of the forces passing through the entire reinforcement that is com-

puted to pass through the fitting considered.

3.17.5. The aggregate strength of the welding attaching any intervening reinforcing plate to the shell plate shall at least equal the proportion of the forces passing through the entire reinforcement, that is computed to pass through the reinforcing plate considered.

3.17.6. The strength of the attachment welding shall be based only on that part of the outer peripheral welding which lies on either side outside the area bounded by vertical lines drawn tangent to the shell opening plus all of the inner peripheral welding that is applied on either side of the plane of reinforcement. This shall be taken as the total shear resistance of the above mentioned attachment welding. The outer peripheral weld shall be made as large as possible and the inner peripheral weld large enough to carry the remainder of the total loading.

3.17.7. In computing the net reinforcing area of a fitting, such as a boiler maker's flange, or a manhole saddle, having a neck, the material in the neck may be considered as part of the reinforcing for a height, measured from the surface of the shell plate or that of an intervening reinforcement plate, equal to four times the thickness of the material in the neck.

Section 4—Design of Standpipes and Reservoirs

4.1. *Standard Capacities:* The standard capacities for standpipes and reservoirs shall be those recommended by the Division of Simplified Practice of the Department of Commerce and shall be as follows:

U. S. Gal.	*U. S. Gal.*
50,000	500,000
60,000	750,000
75,000	1,000,000
100,000	1,500,000
150,000	2,000,000
200,000	2,500,000
250,000	3,000,000
300,000	4,000,000
400,000	

4.2. *Standard Shell Height for Standpipes:* The purchaser shall preferably specify one of the following standard shell heights for standpipes:

Shell Heights from 20 to 50 ft. by even 2-ft. intervals.

Shell Heights from 50 to 100 ft. by even 5-ft. intervals.

Shell Heights from 100 to 200 ft. by even 10-ft. intervals.

The purchaser shall preferably specify the required shell height and the capacity, the exact diameter being determined by the contractor. As here used shell height means height to overflow.

4.3. *Standard Diameters for Reservoirs:* The purchaser shall preferably specify one of the following standard diameters for reservoirs in order to promote standardization of drawings:

Diameters from 20 to 50 ft. by even 2-ft. intervals.

Diameters from 50 to 100 ft. by even 5-ft. intervals.

Diameters from 100 to 200 ft. by even 10-ft. intervals.

For reservoirs the purchaser shall specify the diamter and capacity, the exact height being determined by the contractor.

Section 5—Design of Elevated Tanks

5.1. *Standard Capacities:* The standard capacities for elevated tanks shall preferably be those recommended by the Division of Simplified Practice of the Department of Commerce as follows:

U. S. Gal.	U. S. Gal.	U. S. Gal.
5,000	60,000	500,000
10,000	75,000	750,000
15,000	100,000	1,000,000
20,000	150,000	1,500,000
25,000	200,000	2,000,000
30,000	250,000	2,500,000
40,000	300,000	
50,000	400,000	

5.2. *Standard Heights for Elevated Tanks:* The height of elevated tank structures shall be measured from the underside of the bases of the steel columns to the lower capacity level. The purchaser shall preferably specify one of the following standard heights:

Heights from 20 to 50 ft. by even 2-ft. intervals.
Heights from 50 to 100 ft. by even 5-ft. intervals.
Heights from 100 to 200 ft. by even 10-ft. intervals.

5.3. *Standard Ranges of Head:* By range of head is meant the vertical distance between the lower capacity level and the overflow between which the required capacity is contained. Where range of head is not material the purchaser shall preferably leave the determination of the range of head to the contractor.

If a special "low" range of head is required the purchaser shall preferably specify ranges of head by even 5-ft. intervals.

5.4. *Columns and Struts:* The column base, whether riveted or welded, shall have sufficient area to distribute the column load over the concrete foundations without exceeding the specified bearing stress on the foundation and the connection of the column to the base plate shall provide for the maximum uplift, if the anchors are connected to the base plates and not to the column shaft.

5.5. *Column Splices:* Column splices shall be designed to withstand the maximum possible uplift, or at least 25 per cent of the maximum compression whichever is greater.

If column splices are riveted, the flanges only of rolled column sections need be spliced. Rolled channels, if used in columns, shall have both the flanges and webs spliced. For welded column splices the joints may either be butt welded or splice plates may be welded to both sections being joined.

5.6. *Bottom Struts:* Bottom struts of steel or reinforced concrete shall be provided where necessary to distribute the horizontal reactions at the bases of the columns. These shall consist of struts connecting the foundation piers, or of structural members connecting the lower ends of the columns.

5.7. *Tension Members Carrying Wind and/or Earthquake Loads:* Such members shall be designed to resist the wind load and the earthquake load if the latter is specified. It is not necessary to combine wind and earthquake loads but to design for the maximum stress produced by either force. If the projected centers of gravity of tension members do not meet the projected center of gravity of structural members at the center of gravity of the columns, proper allowance shall be made for the eccentricity.

Diagonal tension members shall be pre-stressed sufficiently to be taut when the tank is full. Such pre-stressing shall not be given consideration in the design of the members.

5.8. *Horizontal Girders:* For elevated tanks with inclined or battered columns connecting to the tank shell a horizontal girder shall be provided to resist the horizontal component of the column loads.

This girder shall be proportioned to withstand safely as a ring girder the horizontal inward component of the load on the top columns.

If the centers of gravity of the horizontal girder, the top section columns and the tank shell do not meet in a point, provision shall be made in the design of each of them for stresses resulting from any eccentricity.

5.9. *Balcony Railing:* If the horizontal girder is used as a balcony it shall be at least 24 in. in width and shall be provided with a railing at least 36 in. in height.

5.10. *Tank Plates:* Plates for elevated tank bottoms, shells and roofs may be any desired shape. Tank plates shall be designed on the basis of the following maximum fiber stresses which shall be reduced for the joint efficiencies as specified elsewhere in these specifications.

Plate surfaces susceptible to complete stress analysis shall be designed on the basis of a maximum fiber stress of 15,000 psi. Such plate surfaces include those not stressed by the concentrated reactions of supporting members or riser pipes.

Plate surfaces not susceptible to complete stress analysis shall also be designed on the basis of the maximum fiber stress of 15,000 psi. after making reasonable allowances for such loads and stresses as cannot be accurately determined. The maximum fiber stress shall in no case exceed 11,000 psi. when calculated assuming that the concentrated reactions of supporting members are uniformly distributed between such reactions.

For example, consider an elevated tank having a vertical cylindrical shell supported by four columns attached to the shell and having a suspended ellipsoidal bottom with a central riser pipe and a cone roof uniformly supported by the tank shell. Under the meaning of these specifications, the stresses in the cylindrical shell and the ellipsoidal bottom cannot be determined, while those in the roof can be completely determined. The shell and bottom shall be designed on the basis of 15,000 psi. maximum fiber stress reduced for the joint efficiency used making allowances for the following:

5.10.1. The hoop stresses caused by the weight or pressure of the tank contents, assuming that the cylindrical tank shell is uniformly supported on its entire lower circumference.

5.10.2. The stresses in the cylindrical shell and ellipsoidal bottom, considering them acting together as a circular girder supported by the column reactions and subjected to torsion because of the portions projecting outward and inward from the chords connecting the columns.

5.10.3. The horizontal inward component of the pull from the tank bottom (in the case of conical or segmental bottoms) causing compression in the tank shell.

5.10.4. Stresses from any other causes.

After the cylindrical shell and bottom have been designed on the above basis, they shall be redesigned assum-

ing that the cylindrical tank shell is uniformly supported on its entire lower circumference, and for this assumption the thicknesses of shell and bottom shall be increased, if necessary, so that the maximum calculated fiber stress shall not exceed 11,000 psi. reduced by the joint efficiency. In the case of riveted joints the redesign shall be based on the rivet values given in Sec. 3.3 reduced by the ratio of 11,000 to 15,000.

In designing bottoms of double curvature, consideration shall be given to the possibility of governing compressive stresses.

It is recognized that no specifications for the design of elevated tanks can be sufficiently specific and complete to eliminate the necessity of judgment on the part of the designer. It is also recognized that strain gage surveys are a proper source of design information.

5.11. *Steel Riser Pipe:* The steel riser pipe shall be designed to withstand stress caused by the weight or the pressure of the tank and riser contents and also the load imposed upon the top of the riser pipe by the tank bottom or by members supporting the tank bottom. If the design of the riser plates is controlled by hoop pressure, 0.3 of the compression in the vertical direction shall be added to the full calculated tension in the horizontal direction in determining the thickness. If controlled by column stresses the allowable column compressive stress shall not exceed the allowable stress calculated in accordance with Sec. 3.5, minus 0.3 of the calculated hoop stress.

The thickness of the bottom ring of the riser shall be sufficient so that the specified unit stresses shall not be exceeded when combined with bending or other stresses around manhole or other openings.

Section 6—Accessories for Standpipes and Reservoirs

6.1. *Shell Manhole:* A circular manhole 24 in. in diameter or an elliptical manhole 18x22 in. minimum size, with cover hinged to shell shall be furnished in the first ring of the tank shell at a location to be designated by the purchaser.

6.2. *Pipe Connection:* The pipe connection shall consist of a fitting of the size specified by the purchaser, attached to the tank bottom at a point designated by the purchaser, into which the connecting pipe may be calked. Unless otherwise specified by the purchaser, the contractor shall furnish the fitting and make the connection to the piping furnished and installed by the purchaser. The top of the fitting shall be flush with the tank floor and provided with a removable silt stop 6 in. high.

6.3. *Overflow:* The tank shall be equipped with an overflow of the type and size specified by the purchaser. A stub overflow is recommended in cold climates. If a stub overflow is specified it shall project at least 12 in. beyond the tank shell. If an overflow to ground is specified it shall be brought down the outside of the tank shell supported at proper intervals with suitable brackets. It shall terminate at the top in a weir box, the weir and connection to the tank to have approximately the same capacity as the overflow pipe specified by the purchaser allowing for full suction head. The top stiffener shall not be cut nor partially removed. The overflow pipe shall terminate at the bottom with a base ell. Unless otherwise specified by the purchaser, the

overflow pipe shall be black steel pipe, with screwed connections if under 4 in. in diameter or flanged connections if 4 in. in diameter or over.

6.4. *Outside Tank Ladder:* The contractor shall furnish a tank ladder on the outside of the tank shell beginning 8 ft. above the level of the tank bottom and at a location to be designated by the purchaser, preferably near the manhole. The sides shall be not less than 2x$\frac{5}{16}$ in. and the rungs not less than $\frac{5}{8}$ in. round or square bars. If a safety cage for this ladder is required by local laws or regulations the purchaser shall so specify.

6.5. *Roof Ladder:* In the case of standpipes with roofs, the contractor shall furnish a roof ladder attached to the roof finial with a swivel connection, the ladder to be equipped with rollers so that it will rotate around the standpipe roof. A roof ladder is not required on standpipe or reservoir roofs having a slope flat enough to walk on safely.

6.6. *Roof Hatch:* For standpipes or reservoirs with roofs, the contractor shall furnish a roof door or hatch, which shall be placed near the outside tank ladder and which shall be provided with hinges and a hasp for locking. The hatch opening shall have a curb at least 4 in. high and the cover shall overlap same at least 2 in.

6.7. *Vent:* In case the tank roof is of tight construction, a suitable vent shall be furnished above the maximum water level which shall have a capacity to pass air so that at the maximum possible rate of the water either entering or leaving the tank, dangerous pressures will not be developed. The overflow pipe shall not be considered to be a tank vent. The tank vent may, however, be combined with the roof finial if desired. The vent shall be so designed and constructed as to prevent the ingress of birds or animals.

6.8. *Additional Accessories:* Any additional accessories required to be furnished shall be specified by the purchaser.

Section 7—Accessories for Elevated Tanks

7.1. *Tower Ladder:* A tower ladder with sides not less than 2x$\frac{5}{16}$ in. and rungs not less than $\frac{5}{8}$ in. round or square shall be furnished extending from a point 8 ft. above the ground up to and connecting with either the horizontal balcony girder or the roof ladder, if no balcony is used. The ladder may be vertical but shall not in any place have a backward slope.

7.2. *Outside Tank Ladder:* In all cases, a ladder shall be provided on the outside of the tank shell connecting either with the balcony or with the tower ladder if no balcony is included. The outside tank ladder shall have sides not less than 2x$\frac{5}{16}$ in. and rungs not less than $\frac{5}{8}$ in. round or square.

7.3. *Roof Hatch:* In all cases, there shall be provided a door or hatch immediately above the high water level, the hatch to have a minimum dimension of at least 24 in. and to be provided with suitable hinges and a hasp to permit locking. Hatch opening shall have a curb at least 4 in. high and the cover shall overlap same at least 2 in.

7.4. *Roof Finial:* The roof shall be provided with a suitable finial.

7.5 *Roof Ladder:* Where practicable, there shall be furnished an outside roof ladder designed to rotate around the roof. If desired the roof

ladder may be swiveled about the tank finial.

7.6. *Vent:* In case the tank roof is of tight construction, a suitable vent shall be furnished above the maximum water level which shall have a capacity to pass air so that at the maximum possible rate of the water either entering or leaving the tank, dangerous pressures will not be developed. The overflow pipe shall not be considered to be a tank vent. The tank vent may, however, be combined with the roof finial if desired. The vent shall be so designed and constructed as to prevent the ingress of birds or animals.

7.7. *Steel Riser Pipe:* In localities where freezing temperatures do not occur, the purchaser may specify a small steel riser pipe. In other locations and unless a small pipe is specified a steel riser pipe not less than 36 in. in inside diameter shall be furnished. In cases where the riser pipe supports a considerable load the riser diameter and thickness shall preferably be determined by the contractor.

In all cases where steel risers are used, there shall be furnished a manhole in the riser shell about three feet from the base of the riser, such manhole to be not less than 12x16 in. in size, the opening to be reinforced or the riser plate so designed that all stresses around the opening are provided for.

The above specified minimum riser diameter of 36 in. shall be increased in cold climates unless the riser is heated to prevent freezing. The proper diameter will depend upon the amount the tank is used and the temperature of the water supplied. In extreme cold climates a minimum diameter of 72 in. is recommended.

A safety grating shall be provided in the top of the riser pipe with no opening larger than 6 in. in width, except that a door at least 12x18 in. shall be provided.

7.8. *Pipe Connection:* The pipe connection into which the connecting pipe may be calked, shall consist of a fitting of the size specified by the purchaser, and shall be attached to the riser bottom at a point designated by the purchaser. Unless otherwise specified by the purchaser, the contractor shall furnish the fitting and make the connection to the piping furnished and installed by the purchaser. The top of the fitting shall be flush with the riser floor and provided with a removable silt stop 6 in. high.

7.9. *Overflow:* The tank shall be equipped with an overflow of the type and size specified by the purchaser. A stub overflow is recommended in cold climates. If a stub overflow is specified, it shall project at least 12 in. beyond the tank shell. If an overflow to ground is specified, it shall be brought down the outside of the tank shell, supported at proper intervals with suitable brackets. It shall terminate at the top in a weir box, the weir and connection to the tank to have approximately the same capacity as the overflow pipe specified by the purchaser, allowing for full suction head. The top angle shall not be cut or partially removed. The overflow pipe shall terminate at the bottom with a base ell. Unless otherwise specified by the purchaser, the overflow pipe shall be black steel pipe, with screwed connections if under 4 in. in diameter or flanged connections if 4 in. or over in diameter.

7.10. *Additional Accessories:* Any additional accessories required to be furnished shall be specified by the purchaser.

Section 8—Welding

8.1. *Definitions and Symbols:*

8.1.1. Welding terms employed in these rules shall be interpreted according to the definitions given in the latest edition of "Definitions of Welding Terms and Master Chart of Welding Processes," issued by the American Welding Society.

8.1.2. Symbols used on construction drawings shall conform to those shown in the latest edition of "Standard Welding Symbols," issued by the American Welding Society.

8.2. *Qualification of Welding Procedures and Welding Operators:* All welding procedures and welding operators employed in the construction of tanks under these specifications shall be qualified in accordance with the requirements of the latest edition of the American Welding Society "Standard Qualification Procedure" using the test values and modifying conditions prescribed in Pars. 8.2.1, 8.2.2, 8.2.3 and 8.2.4.

8.2.1. *Qualification of Welding Procedures:* The contractor shall submit a report on the qualification tests of the welding procedures, including all of the types of welded joints in all the positions of welding he intends to use in the construction. These test reports shall bear proper witness certification of a reputable testing laboratory or inspection agency, attesting that such tests were performed in accordance with the requirements of these specifications governing the qualification of welding procedures. Requalification of a welding procedure shall not be required provided that the procedure is not modified in any variable beyond the limits prescribed for that variable in the American Welding Society "Standard Qualification Procedure."

8.2.2. *Groove Welds in Joints Subject to Primary Stress:* (joints subject to primary stress due to weight or pressure of tank contents):

a. Thicknesses greater than 1½ in. shall be qualified in the maximum thickness to be welded. (See Par. 10.7.)

b. Reduced-Section Tension Test—The tensile strength of the welded specimen shall be not less than 95 per cent of the minimum of the specified A.S.T.M. tensile range of the base material.

c. Free-Bend Test—The elongation of the welded specimen shall be not less than 20 per cent.

d. Root-, Face- and Side-Bend Test—Any specimen in which a crack or other open defect is present after bending, exceeding ¼ in. measured in any direction, shall be considered as having failed. Cracks occurring on the corners of the specimens during testing shall not be considered.

8.2.3. *Groove Welds in Joints Subject to Secondary Stress* (joints subject to secondary stress and not directly affected by the weight or pressure of tank contents; complete fusion of the joint is not required):

a. Reduced-Section Tension Test—The tensile strength of the welded specimen shall be not less than 110 per cent of the specified strength of the joint.

b. Free-Bend Test—This test shall be omitted.

c. Root-, Face- and Side-Bend Test—These tests shall be omitted.

8.2.4. *Fillet Welds:*

a. Transverse Shear Test—The transverse shear strength of the welded specimen, in pounds per square inch, shall be not less than 87½ per cent of

the minimum of the specified A.S.T.M. tensile range of the base material.

b. Longitudinal Shear Tests—The longitudinal shear strength of the welded specimen, in pounds per square inch, shall be not less than 67 per cent of the minimum of the specified A.S.T.M. tensile range of the base material.

c. Fillet-Weld Soundness Test—Any specimen in which a crack or other open defect is present after bending, exceeding $\frac{1}{8}$ in. measured in any direction, shall be considered as having failed. Cracks occurring on the corners of the specimen during testing shall not be considered.

8.2.5. *Qualification of Welding Operators:*

a. The contractor shall certify that all welding operators employed by him have been qualified as required by these specifications.

b. An operator who has successfully passed the required qualification tests shall be deemed qualified indefinitely, provided: (1) he has not changed his employer; (2) he has been in the meantime continuously employed on similar work, except for periods, no one of which exceeds three months, and with the total idle time not exceeding his working time in each six months' period; and (3) there is no specified reason to question his ability. In case (2) above, the Qualification Test need be made only in the $\frac{3}{8}$ in. thickness.

c. An operator who has been qualified for welding on plates will be permitted to perform the incidental pipe welding required in the fabrication and attachment of tank appurtenances.

d. The contractor shall maintain a record of the welding operators employed by him, showing the dates and results of Qualification Tests and the work-identification mark assigned to each operator.

8.3. *Butt Joints Subject to Primary Stress Due to Weight or Pressure of Tank Contents* (e.g., vertical joints of cylindrical tank shells; all joints below the point of support in suspended bottoms of elevated tanks): These joints shall have complete penetration welds, which may be double welded or welded from one side only, using a backing strip or equivalent means to insure complete penetration.

8.4. *Butt Joints Subject to Secondary Stress* (e.g., horizontal joints of cylindrical tank shells): These joints shall be double welded and shall be designed to develop an efficiency of at least 57 per cent, based upon the thickness of the thinner plate joined. Single groove welded joints shall have complete penetration. Square groove and double groove welded joints may have partial penetration, provided the unwelded portion does not exceed one-third ($\frac{1}{3}$) the thickness of the thinner plate at the joint, and provided the unwelded portion is located substantially at the center of the thinner plate. Any joint of this type shall have a strength at least equivalent to two-thirds ($\frac{2}{3}$) that of a double welded butt joint having complete penetration.

8.5. *Lap Joints Subject to Primary Stress Due to Weight or Pressure of Tank Contents* (e.g., vertical joints of cylindrical tank shells; all joints below the point of support in suspended bottoms of elevated tanks): These joints shall have continuous full-fillet welds on both edges of the joint. (Maximum thickness permitted for this type of joint is $\frac{1}{2}$ in.)

8.6. *Lap Joints Subject to Secondary Stress* (e.g., horizontal joints of cylindrical tank shells): These joints shall be welded on both sides with continuous fillet welds. They shall be designed to develop an efficiency of at least 50 per cent based upon the thick-

ness of the thinner plate joined. Any joint of this type shall have a strength at least equivalent to two-thirds ($\frac{2}{3}$) that of a lap joint having full-fillet welds on both edges. (Maximum thickness permitted for this type of joint is $\frac{5}{8}$ in.)

8.7. *Flat Tank Bottoms Resting Directly on Grade or Foundation:* Bottoms shall be built to one of two alternative methods of construction:

8.7.1. *Lap Joint Construction:* Bottom plates need be welded on the top side only with continuous full-fillet welds on all seams.

Marginal sketch plates under the bottom ring of cylindrical shells, in the case of lap joint construction, shall have the outer end of the joint fitted and welded with groove or fillet welds to form a smooth bearing under the shell. (Maximum thickness for lap welded bottoms shall be $\frac{1}{2}$ in.)

8.7.2. *Butt Joint Construction:* These joints shall be single welded from the top side, using suitable backing strip or equivalent means to insure complete penetration.

8.8. *Shell to Bottom Joint* (applies to vertical cylindrical shells with flat bottoms): The bottom edge of the lowest course shell plates and the bottom sketch plates shall be joined by continuous fillet welds on both sides of the shell plate. The size of each weld shall be equal to the thickness of the sketch plate or the thickness of the shell plate, whichever is smaller, with a maximum size of $\frac{1}{2}$ in. The sketch plate shall extend outside the tank shell a distance of at least 1" beyond the toe of the weld.

8.9. *Roof Plates:*

8.9.1. Roofs not subject to hydrostatic pressure from tank contents—such roof plates need be welded on the top side only with continuous full-fillet welds on all seams.

8.9.2. Roofs subject to hydrostatic pressure from tank contents—such roof plate joints shall be designed to conform to the efficiency values given in Sec. 3.16.

8.10. *Maximum Thickness of Material to Be Welded:*

8.10.1. The maximum thickness of material to be used for lap joints subject to primary stress due to weight or pressure of tank contents shall be $\frac{1}{2}$ in. (e.g., vertical joints of cylindrical tank shells; all joints below the points of support in elevated tanks).

8.10.2. The maximum thickness of material to be used for lap joints subject to secondary stress shall be $\frac{5}{8}$ in. (e.g., horizontal joints of cylindrical tank shells).

8.10.3. The maximum thickness of material to be used for lap joints in flat tank bottoms resting directly on grade or foundation shall be $\frac{1}{2}$ in.

8.10.4. Butt joints may be used for welding all thicknesses of material permitted to be welded under these specifications.

8.10.5. The maximum thickness of material permitted to be welded under these specifications shall be 2 in. (See Par. 8.2.2. (a) and 10.7.)

8.11. *Minimum Laps for Lap Joints:*

8.11.1. The minimum lap for joints subject to primary stress due to the weight or pressure of tank contents shall be 5 T (e.g., vertical joints of cylindrical tank shells; all joints below the point of support in suspended bottoms).

8.11.2. The minimum lap for joints subject to secondary stress shall be 3 T but not less than 1 in. (e.g., horizontal joints of cylindrical shells, flat tank bot-

toms and roofs not subject to hydrostatic pressure from tank contents).

Where T is the thickness of the material to be welded. In a joint involving two different thicknesses, the thickness of the thinner plate shall be used.

8.12. *Intermittent Welding:*

8.12.1. The length of any segment of intermittent weld shall be not less than four times the weld size but in no case less than 1½ in.

8.12.2. Intermittent welding shall not be used on tank shell plating.

8.12.3. Intermittent groove welds shall not be used.

8.12.4. All seams which are to have intermittent welds shall have continuous lengths of welds at each end for a distance of at least 6 in.

8.13. *Minimum Size of Fillet and Seal Welds:*

8.13.1. Plates $\frac{3}{16}$ in. and less in thickness shall have full-fillet welds. Plates over $\frac{3}{16}$ in. thick shall have welds of a size not less than $\frac{1}{3}$ the thickness of the thinner plate at the joint, with a minimum of $\frac{3}{16}$ in.

8.13.2. Seal welding, when desired, shall preferably be accomplished by a continuous weld combining the functions of sealing and strength, changing section only as the required strength may necessitate.

8.14. *Minimum Length of Welds:*

8.14.1. The minimum length of any weld shall be four times the size, but not less than 1½ in., or else the size of the weld shall be considered not to exceed one-fourth ($\frac{1}{4}$) its length.

8.14.2. The effective length of a fillet weld shall not include the length of tapered ends. A deduction of at least ¼ in. shall be made from the overall length as an allowance for the tapered ends.

Section 9—Shop Fabrication

9.1. *Workmanship:* All workmanship done on tanks being built under these specifications shall be first class in every respect.

9.2. *Straightening:* Any required straightening of material shall be done by methods which will not injure the steel. Straightening by hammering will not be permitted but shall be done cold by rolling or pressing.

9.3. *Laying Out:* Laying out shall be done by experienced workmen only. Rivet holes shall be accurately spaced so that they come opposite each other in adjoining parts. If, upon assembling, holes do not match within $\frac{1}{8}$ in. for punched holes or $\frac{1}{16}$ in. for drilled or reamed holes, the inspector may order the contractor to ream the holes to a larger size and to use larger rivets, or, if the error is too great to permit this, the plate or plates containing such unfair holes may be rejected at the option of the inspector.

9.4. *Rivet Holes:* Rivet holes in material $\frac{5}{8}$ in. thick and under may be punched or drilled full size. Rivet holes in material over $\frac{5}{8}$ in. to and including $\frac{3}{4}$ in. thick shall be either drilled from the solid or punched $\frac{1}{16}$ in. smaller in diameter than the nominal diameter of the rivet and then reamed to size. Rivet holes in material over $\frac{3}{4}$ in. thick shall be drilled.

The final diameter of rivet holes shall be not more than $\frac{1}{16}$ in. larger than the rivets.

9.5. *Plate Edges—Riveted Work:* Edges of plates which are to be calked shall be beveled either by shearing, machining, or cutting with a machine operated gas torch, except that plates over $\frac{5}{8}$ in. thick shall not be sheared.

Plates $\frac{1}{2}$ in. and less in thickness may

be beveled to approximately a 60- to 70-deg. angle. Plates over ½ in. in thickness may be beveled to an angle of approximately 75 to 80 deg.

9.6. *Finish of Plate Edges—Welded Work:*

9.6.1. The plate edges to be welded may be universal mill edges or they may be prepared by shearing, machining, chipping, or by mechanically guided gas cutting, except that edges of irregular contour may be prepared by manually guided gas cutting.

9.6.2. When edges of plates are gas cut, the surface obtained shall be uniform and smooth and shall be cleaned of slag accumulations before welding. All cutting shall follow closely the lines prescribed.

9.6.3. Shearing may be used for material ½ in. or less in thickness to be joined by butt joints, and for all thicknesses of material permitted to be joined by lap joints.

9.7. *Scarfing for Riveted Construction:* Scarfing may be done either by heating the corners to be scarfed to a cherry-red color, then forging while hot, or the scarf may be made by forging in the cold either by hydraulic or mechanical pressing.

9.8. *Rolling:* Plates shall be cold rolled to the proper curvature in accordance with the following table.

Plate Thickness	*Minimum Diameter for Plates Not Rolled*
Plates less than ⅜ in.	30 ft.
⅜ in. to less than ½ in.	60 ft.
½ in. to less than ⅝ in.	120 ft.
⅝ in. and heavier	Must be rolled for all diameters

All butt straps are to be formed to the proper curvature.

9.9. *Double Curved Plates:* Plates which are curved in two directions may be pressed either cold or hot or may be dished with a "mortar and pestle" die by repeated applications.

9.10. *Milling Columns:* The ends of columns shall be milled to provide a satisfactory bearing unless the design contemplates sufficient riveting or welding to resist the total calculated loads.

9.11. *Shop Assembly:* Double-curved tank bottoms, shells, and roofs, shall be assembled in the shop, if necessary, to insure their fitting properly in the field.

9.12. *Shipping:* All materials shall be loaded on cars, unloaded, transported to the site and stored in such manner as to prevent damage.

Section 10—Erection

10.1. *General:* The contractor shall furnish all labor, liability and compensation insurance, tools, falsework, scaffolding and other equipment necessary and erect the tank complete ready for use. He shall furnish to the purchaser certificates of insurance coverage.

10.2. *Riveted Tanks:* Plates shall be carefully and accurately laid up and shall then be firmly drawn together with machine bolts or wedge bolts before riveting is started.

No paint or foreign materials shall be used between surfaces in contact.

Rivets under ⅞ in. in diameter may be driven hot or cold. All rivets ⅞ in. in diameter and larger shall be driven hot.

Hot driven rivets shall be driven by pneumatic or hydraulic tools whenever possible.

Rivets shall be driven with either cone, steeple or button shaped snaps, except that cold rivets may be driven with mushroom heads.

Heads shall be as nearly as possible concentric with the rivet body. All

rivets shall be driven from the side of the plate which calks.

Any burned, loose or defective rivets shall be cut out and redriven.

Riveted seams shall be made tight by calking. The portion of the roof, if any, containing water shall be calked; the remainder of the roof need not be calked. Calking tools and methods used shall be such that the underlying sheet is not damaged and the edge of the top sheet is not turned under. The work must be done by experienced men only.

The opening between ends of plates and outside butt straps shall be stopped by means of a wedge or by welding.

10.3. *Welded Tanks:* If painting is required on underside of flat tank bottom, the bottom plates shall be spread out and painted. After the paint has dried the plates shall be moved to their proper location on the foundations and turned over in place with as little subsequent moving as possible in order not to damage the paint film.

The bottom plates shall be assembled and welded together following a procedure which will result in a minimum of distortion from weld shrinkage.

All shell, bottom and roof plates subjected to stress by the weight or pressure of the contained liquid shall be assembled and welded in such a manner that the proper curvature of the plates in both directions is maintained.

Extra holes in the plates for erection purposes may be used provided the holes are later filled with rivets or weld metal in compliance with Sec. 11.9.

Any clips, jigs or lugs welded to the shell plates for erection purposes shall be removed without damaging the plates and any portion of weld beads remaining shall be chipped or ground smooth.

10.4. *Welds—General:* All welds in the tank and structural attachments shall be made in a manner to insure complete fusion with the base metal, within the limits specified for each joint, and in strict accordance with the qualified procedure.

10.5. *Preparation of Surfaces to Be Welded:* Surfaces to be welded shall be free from loose scale, slag, heavy rust, grease, paint and any other foreign material excepting tightly adherent mill scale. A light film of linseed oil or spatter film compound may be disregarded. Such surfaces shall also be smooth, uniform and free from fins, tears, and other defects which adversely affect proper welding. A fine film of rust, adhering on cut or sheared edges after wire-brushing, need not be removed.

10.6. *Weather Conditions:* Welding shall not be done when the temperature of the base metal is lower than 0° F.; when surfaces are wet from condensation, rain, snow or ice; when rain or snow is falling on the surfaces to be welded; nor during periods of high wind, unless the welding operator and the work are properly protected. At temperatures between 32° F. and 0° F., the surfaces of all areas within 3 in. of the point where the weld is to be started shall be heated to a temperature warm to the hand before the welding is started.

10.7. *Preheating and Interpass Temperature:* When the thickness of materials to be welded exceeds 1½ in., the surfaces within a minimum distance of four times the thickness from the edges where welding is to be started shall be heated to a temperature of 200° F., and at least this temperature shall be maintained for four thicknesses each side of the arc as welding progresses.

10.8. *Cleaning Between Beads:* Each bead of multiple-pass weld shall

be cleaned of slag and other loose deposits before applying the next bead.

10.9. *Tack Welds:* Tack welds used in erection for the assembly of joints subject to primary stress from the weight or pressure of the tank contents and those used for assembling the tank shell to the bottom are to be removed ahead of the continuous welding. Tack welds used in the assembly of joints subject to secondary stress, such as those used in flat bottoms, roofs and circumferential seams of cylindrical tank shells, need not be removed, provided that they are sound and the subsequent beads are thoroughly fused with the tack welds.

10.10. *Peening.*

10.10.1. Peening of weld layers may be used to prevent undue distortion. Surface layers shall not be peened.

10.10.2. Peening shall be performed with light blows from a power hammer using a blunt-nosed tool.

10.11. *Weld Contour.*

10.11.1. In all welds, the surface beads shall merge smoothly into each other.

10.11.2. Undercutting of base metal in the plate adjoining the weld shall be repaired, except as permitted in sections 11.8.7 and 11.8.8.

10.11.3. All craters shall be filled to the full cross-section of the weld.

10.12. *Weld Reinforcement:* The reinforcement of butt welds shall be as small as practicable, preferably not more than $\frac{1}{16}$ in. In no case shall the face of the weld lie below the surface of the plates being joined.

10.13. *Chipping and Gas-Gouging of Welds:* Chipping of the roots of welds and chipping of welds to remove defects may be performed with a round-nosed tool or by gas-gouging.

10.14. *Flat Tank Bottoms:* The bottom plates, after being laid out and tacked, shall be joined by welding the joints in a sequence which the contractor has found to result in the least distortion due to shrinkage of the welding, and to provide, as nearly as possible, a plane surface.

10.15. *Tank Shell:*

10.15.1. For welding in the vertical position the progression of welding shall be either upward or downward, according to the direction specified in the welding procedure and used for operator qualification.

10.15.2. The shell plates shall be joined by welding the joints in a sequence which the contractor has found to result in the least distortion due to shrinkage of the welding and which will avoid kinks at the vertical joints.

10.16. *Matching Plates:*

10.16.1. *Lap Joints:* The plates forming a lap joint shall be held in as close contact as possible during welding, and in no case shall the separation be more than $\frac{1}{16}$ in. Where separation occurs, the size of weld shall be increased by the amount of the separation.

10.16.2. *Butt Joints* (primary stress): In butt joints subject to primary stress from weight or pressure of tank contents, the adjoining plates shall be accurately aligned and retained in position during welding, so that in the finished joint, the center lines of adjoining plate edges shall not have an offset from each other, at any point, in excess of 10 per cent of the plate thickness (using the thickness of the thinner plate if of different thicknesses) or $\frac{1}{16}$ in., whichever is larger.

10.16.3. *Butt Joints* (secondary stress): In butt joints subject to secondary stress, the adjoining plates shall be accurately aligned and retained in position during welding, so that in the finished joint, the thinner plate (if one

is thinner than the other), or either plate (if both plates are of the same thickness), shall not project beyond its adjoining plate by more than 20 per cent of the plate thickness (using the thickness of the thinner plate if of different thicknesses), or $\frac{1}{8}$ in., whichever is smaller.

10.17. *Grouting Column and Riser Bases:* After the tank has been completely erected and trued up, any space which may exist between column and riser bases and foundations shall be thoroughly wetted and filled with a 1 : 1 cement-sand grout forced under the base plates and filling the space completely. The materials and labor for the grouting are to be furnished by the contractor.

10.18. *Sand Cushion:* A sand cushion not less than 1 in. in thickness shall be provided under riveted flat tank bottoms on concrete slab foundations. The sand shall be furnished at the site by the purchaser and spread by the contractor. In the case of both riveted and welded tanks, after the tank has been completely erected, any space which may exist between the tank bottom and the concrete foundation, and extending for a distance of at least 18 in. inside the tank shell, shall be filled with a 1 : 1 cement-sand grout forced under the bottom so as to fill completely the space. The top of the foundations shall be thoroughly saturated with water before the grout is poured. The materials and labor for grouting are to be furnished by the contractor.

10.19. *Cleaning Up:* Upon completion of the erection, the contractor shall remove or dispose of all rubbish and other unsightly material caused by his operations and shall leave the premises in as good a condition as he found them.

Section 11—Inspection

11.1. *Riveted or Welded Tanks:* The purchaser may, if he so specifies, require mill and/or shop inspection by a commercial inspection agency, the cost of which shall be paid by the purchaser. Copies of the mill test reports shall be furnished the purchaser if requested.

11.2. *Field Inspection:* It is required under these specifications that the field welding be inspected in the following manner by a qualified welding inspector designated by the purchaser. The contractor shall furnish equipment for trepanning or otherwise obtaining inspection specimens.

The quality of all accessible welds which carry stress from weight or pressure of tank contents shall be inspected by sectioning methods.

11.3. *Application:* The examination of the welded structure by sectioning methods is more satisfactory when applied to butt joints, which makes it highly desirable that the shell of the all-welded tank be constructed with butt joints throughout. While it is possible to cut sections from lap joints, it will require twice as many sections on the double-fillet-welded joints to obtain as many sections per unit length of joint as for butt joints.

11.4. *Sectional Specimens:*

11.4.1. Sectional specimens are segments cut from the welded joints with a circular cutting tool or spherical saw, which removes a portion of the plate bounding the welded joint and exposes thereon two (2) cross-sections of the weld. The segments must

expose the full cross-section of the welded joint.

11.4.2. Segments cut with a circular tool are called trepanned plugs; segments cut with a spherical saw are called spherical segments.

11.5. *Number and Location of Test Segments:*

11.5.1. Removal of sectional specimens shall be confined to tank shell joints, particularly those subject to primary stress from weight or pressure of tank contents. It need not be applied to flat tank bottoms resting directly on grade or foundation, nor to the welds between flat tank bottoms and the first ring of tank shell, nor to the welds connecting top curb angle to shell and to roof, nor to roofs not subject to primary stress from weight or pressure of tank contents, nor to welds connecting manholes and other accessories.

11.5.2. Test Segments shall be taken as the work progresses, as soon as practicable after all the joints accessible from one scaffold position have been welded.

11.5.3. The location for cutting the test segments may be determined by the purchaser's inspector.

11.5.4. Spherical segments shall be cut from the outside of the tank shell for butt joints and from the welded surface for lap joints.

11.5.5. Segments shall be cut from lap joints in pairs, one from each fillet weld. They shall not be removed on the same center line, but shall be offset by approximately 3 in. measured parallel to the axis of the joint.

11.5.6. *Joints Subject to Primary Stress Due to Weight or Pressure of Tank Contents:* One segment shall be cut from the first 10 ft. of completed joint welded by each operator. Thereafter, one additional segment shall be cut from approximately every 100 ft. or any remaining major fraction thereof of joint of the same type and thickness in the structure.

11.5.7. *Joint Subject to Secondary Stress:* One segment shall be cut from the first 10 ft. of completed joint; thereafter, one additional segment shall be cut from approximately every 200 ft. of joint and any remaining major fraction thereof, of the same type and thickness (based upon the thickness of the thicker plate at the joint).

11.5.8. Insofar as practicable, an equal number of segments shall be cut from the welding performed by each welding operator, except where the length of joint welded by an operator is very much less than the average. One segment may be used to test the work of two operators when they have welded opposite sides of the same joint. If such a segment is rejected, subsequent tests of each operator's work shall be used to determine whether one or both operators were at fault.

11.6. *Size of Sectional Segments:*

11.6.1. Segments shall be removed approximately from the center of the weld. The width or diameter of a segment shall be not less than the width of the finished weld, plus $\frac{1}{2}$ in. and in no case less than $\frac{1}{2}$ in.

11.7. *Preparation of Sectional Segments:*

11.7.1. Sectional segments may be etched for inspection by any of the following methods.

(1) Without requiring any finishing or other preparation, place in boiling 50 per cent solution of muriatic (hydrochloric) acid until there is a clear definition of the structure of the weld. This will require approximately 30 min.

(2) Grind and smooth segments with emery wheel and/or emery paper and then etch by treating with a solu-

tion of one part ammonium persulfate and nine parts of water by weight. The solution should be used at room temperature and should be applied by vigorously rubbing the surface to be etched with a piece of cotton kept saturated with the solution. The etching process should be continued until there is a clear definition of the structure of the weld.

(3) Grind and smooth segments with emery wheel and/or emery paper and then etch by treating with a solution of one part of powdered iodine (solid form), two parts of powdered potassium iodide, and ten parts of water, all by weight. The solution should be used at room temperature and should be brushed on the surface to be etched until there is a clear definition of the structure of the weld.

11.7.2. To preserve the appearance of the etched segments they should, after etching, be washed in clear water, the excess water removed, then immersed in ethyl alcohol, and dried. The etched surfaces may then be preserved by coating with a thin, clear lacquer.

11.8. *Inspection of Sectional Segments:*

11.8.1. The etched segments shall be examined to ascertain the extent of weld defects, such as gas pockets, slag inclusions, lack of fusion, undercutting and cracks.

11.8.2. For all welds, the etched surfaces of the segments shall show complete fusion between the weld metal and the base metal within the depth of the weld required for the applicable joint. There shall be no cracks in any weld.

11.8.3. For butt joints, slag inclusions shall not be permissible except where they occur between layers of the weld, are substantially parallel to the plate surface, and are equal to not more than one-half the width of the weld; or where they occur across the depth of the weld and are equal to not more than 10 per cent of the thickness of the thinner plate joined.

11.8.4. For lap joints, slag inclusions shall not be permissible except where they occur between layers of the weld, are substantially parallel to the face of the weld, and are equal to not more than one-half the width of the weld, measured in a direction parallel to the face of the weld; or where they occur across the throat of the weld and are equal to not more than 10 per cent of the throat.

11.8.5. Gas pockets shall not be permissible except where they do not exceed $\frac{1}{16}$ in. in greatest dimension and where there are no more than six gas pockets, not exceeding the maximum permissible size, per square inch of weld metal; or where the combined area of a greater number of gas pockets does not exceed 0.02 sq.in. per square inch (2 per cent) of weld metal.

11.8.6. For butt and lap joints subject to primary stress due to weight or pressure of tank contents, there shall be complete penetration and no undercutting.

11.8.7. For butt joints subject to secondary stress, penetration is only required within the limits established by Sec. 8.4. A maximum undercut of $\frac{1}{32}$ in. at each edge of the weld may be permitted, provided the unwelded portion plus the undercut shall not reduce the thickness of the joint more than $\frac{1}{8}$ of the thickness of the thinner plate joined.

11.8.8. For lap joints subject to secondary stress, the maximum undercut permitted shall be $\frac{1}{32}$ in. deep, measured along either leg of the weld. The maximum amount of lack of penetration permitted at the root of the weld

shall be $\frac{1}{16}$ in., measured along either leg or through the throat of the weld, provided the size of the weld is increased to compensate for lack of penetration.

11.8.9. Where a defective segment is located, additional segments shall be cut from the same operator's work 2 ft. on each side of the defective segment, wherever the joint length will permit. If additional defective segments are found, then more segments shall be cut at intervals of 2 ft. on the same operator's work until the limit of the defective welding has been definitely established; or the contractor may proceed to replace all the welding done by that operator without cutting out additional segments.

11.8.10. Defects in welds shall be removed by chipping or by gas-gouging from one or both sides of the joint and rewelding. Removal of defective welds is required only to the extent necessary to correct the defects present. Repaired welds shall be inspected by repeating the original test procedure.

11.9. *Method of Closing Openings:* Subject to the stated limitations, openings caused by the removal of segments or those made for scaffold brackets or other constructional purposes, may be closed by any of the following methods:

11.9.1. *Openings Cut With a Spherical Saw:* Openings cut with a spherical saw shall be completely filled with weld metal. Fillet welds, where cut, shall be rebuilt to their original contour. In butt joints, a backing plate, if necessary, shall be placed on the inside of the tank shell over the opening; in lap joints, the base material opposite the weld will usually serve as a backing plate.

11.9.2. *Trepanned Plug Openings in Joints Subject to Secondary Stress Only,* or openings not in joints, for scaffold brackets or other constructional purposes: Such openings may be filled by inserting a disc in the hole in a mid-position between the surfaces of the thinner plate for butt joints and in a mid-position of the continuous plate for lap joints. The disc shall be at least $\frac{1}{8}$ in. thinner than the thickness of the thinner plate in the joint and shall have a fairly close fit in the hole. The upper side of horizontal or partially horizontal holes on each side of the disc shall be tapered sufficiently to permit depositing a sound weld in the opening. Both sides of the disc shall be welded over completely, fusing the circular edges of the disc with the plate and making the surfaces of the weld substantially flush with the plate surfaces. Fillet welds, where cut, shall be rebuilt to their original contour.

11.9.3. *Trepanned Plug Openings in Joints Subject to Primary or Secondary Stress;* or openings, not in joints, for scaffold brackets or other constructional purposes; where the thickness of the plate, or the thinner plate at the joint, is not greater than one-third ($\frac{1}{3}$) the diameter of the hole: Such openings shall be filled completely with weld metal applied from the outside of the tank shell. Before welding, place a backing plate on the inside of the tank shell over the opening, taper the upper side of horizontal or partially horizontal holes, from the backing plate outward, sufficiently to permit depositing a sound weld in the opening. Fillet welds, where cut, shall be rebuilt to their original contour.

11.9.4. *Trepanned Plug Openings in Joints Subject to Primary or Secondary Stress;* or openings, not in joints, for scaffold brackets or other constructional purposes; where the thickness of the plate, or the thinner

plate at the joint, is not less than $\frac{1}{3}$, nor greater than $\frac{2}{3}$ the diameter of the hole: Such openings shall be filled completely with weld metal applied from both sides of the tank shell. Before welding, taper the upper side of horizontal or partially horizontal holes, from the center outward, on both sides of the plate, sufficiently to permit depositing a sound weld in the opening. Fillet welds, where cut, shall be re-built to their original contour.

11.9.5. *Trepanned Plug Openings in Butt Joints Subject to Primary or Secondary Stress;* or openings, not in joints, for scaffold brackets or other constructional purposes; where the thickness of the plate, or the thinner plate at the joint, does not exceed $\frac{7}{8}$ in.: Such holes shall be filled completely with weld metal applied from the outside of the tank shell. Before welding, place a backing plate on the inside of the tank shell or a thin disc (not over $\frac{1}{4}$ in. thick) at the bottom of the hole; chip a groove on the outside of the plate, extending from the hole in opposite directions. The length of the groove on each side of the opening is to have a slope of about 1 in $1\frac{1}{2}$ extending from the bottom of the hole to the surface. The groove at the opening shall have sufficient width to provide a taper to the bottom of the hole to permit depositing a sound weld in the opening.

11.9.6. *Trepanned Plug Openings in Butt Joints Subject to Primary or Secondary Stress;* or openings, not in joints, for scaffold brackets or other constructional purposes, for plates of any thickness: Such holes shall be filled completely with weld metal applied from both sides of the plate. Before welding, place a thin disc (not over $\frac{1}{4}$ in. thick) in the hole at the middle of the plate, chip a groove on both sides of the plate, extending from the hole in opposite directions. The length of the groove on each side of the opening is to have a slope of about 1 in $1\frac{1}{2}$ extending from the middle of the plate to the surface.

The groove at the opening shall have sufficient width to provide a taper to the middle of the plate to permit depositing a sound weld in the opening.

11.10. *Record of Segments:*

11.10.1. The segments, after removal, shall be properly stamped or tagged for identification; and, after etching, kept in proper containers, with a record of their place of removal as well as of the welding operator who performed the welding. A record shall be made by the inspector, of all segments, with their identification marks on a developed shell-plate diagram.

11.10.2. After the completion of the structure, the segments may be retained by the purchaser, if he so desires; otherwise they may be discarded.

11.11. *When Inspected:* It is required that the inspector be on the job before any welding is done, at which time the welding operators shall be qualified or their credentials accepted, after which welding may proceed. It is recommended that the inspector make the examination of the trepanned plugs immediately after the first vertical joints are welded to prevent a large amount of unacceptable welding being done which would later have to be removed. The inspector need, however, stay only until he is satisfied that acceptable work is being done, after which he may leave and then return when the welding to be inspected has been completed so that he may complete his inspection of the welds. The inspector shall, however, visit the job at least once during each month that the work is in progress.

11.12. *Who Pays for the Field Inspection:* The purchaser shall pay the cost of the field inspection. If the inspector is required to work a greater number of days, because of repeated tests due to faulty work or of additional trips to reinspect rejected work, the contractor shall pay the increased cost of such inspection over what it would have been if there had been no faulty or rejected work. The inspector shall report to the purchaser any instances where the contractor fails to repair any rejected work which controversy shall be settled between the purchaser and the contractor in a manner satisfactory to them. Upon completion of the work the inspector shall send a written acceptance of the workmanship to the purchaser and at the same time shall send a copy of such acceptance to the contractor.

Section 12—Testing

12.1. *Riveted Flat Bottoms:* Riveted flat tank bottoms shall be tested on horses before being lowered to the grade. Sufficient water shall be placed in the bottom to cover the bottom angle. Any leaks shall be corrected by calking or redriving rivets, if necessary.

12.2. *Welded Flat Bottoms:* After the bottom has been welded completely, including the attachment of at least the lowest shell course, water, to be supplied by the purchaser, may be pumped underneath the bottom, maintaining a head of at least 6 in. of liquid, by holding that depth around the edge of the bottom inside a temporary dam; or the joints may be tested with a suitable material such as strong soap solution or linseed oil under air pressure or vacuum; or the joints may be tested by the magnetic particle method. The bottom shall be made entirely tight to the satisfaction of the purchaser's inspector.

12.3. *General:* Upon completion of the tank, before it is painted, it shall be filled with water furnished at the tank site by the purchaser at proper pressure to fill the tank to the maximum working water level. Any leaks which are disclosed in this test in either the shell, bottom, or roof (if the roof contains water), shall be repaired by calking for riveted construction and by drilling, chipping or gas-gouging any defective welds and then rewelding for welded construction. No repair work shall be done on any joints unless the water in the tank is at least 2 ft. below the point being repaired.

12.4. *Disposal of Test Water:* The purchaser shall provide means for disposing of test water up to the tank inlet or drain pipe.

Section 13—Field Painting

13.1. *General:* After completion of a satisfactory test, the tank shall be painted or coated in accordance with the purchaser's specifications. See Sec. A7 to A11 inclusive for recommended paints and methods of protecting the tank against corrosion.

13.2. *Workmanship:* All painting shall be done in a workmanlike manner. The surfaces shall be cleaned of foreign material and if no shop paint has been applied, the steel shall be wire-brushed before applying the first coat of field paint.

If the purchaser specifies that the mill scale be removed, and if pickling or sandblasting is not specified, it shall be understood that the rust and loose

mill scale shall be removed by wire brushing only.

13.3. *Painting:* After cleaning, the work shall be given the required number of coats of paint or other materials as specified by the purchaser and in the manner recommended by the manufacturer of such materials. Sufficient time shall be allowed for each coat to dry thoroughly before the following coat is applied.

13.4. *Aluminum Paint:* Where aluminum paint is specified for the exterior of the tank, the contractor shall apply the paint either by brush or spray, at his option, unless the manner of application is specified by the purchaser. The paint shall be applied as smoothly as possible.

Appendix

A1. *General:* This appendix contains recommendations which are believed to represent good practice but they are not to be considered as requirements of the specifications.

A2. *Information to Be Furnished by Purchaser for an Elevated Tank:*

A2.1. Capacity.

A2.2. Height to bottom capacity level or to overflow.

A2.3. Roof pitch and projection at eaves (unless the purchaser wishes to leave to the contractor the selection of proper and appropriate dimensions).

A2.4. The range of head, if special range is required.

A2.5. Type of joint construction, whether riveted or welded, if there is a preference.

A2.6. Diameter and kind of riser pipe.

A2.7. The desired time for completion.

A2.8. Location of site.

A2.9. Type of road available for access to the site and whether public or private.

A2.10. Name of and distance to nearest town.

A2.11. Name of and distance to nearest railroad siding.

A2.12. Availability of electric power, who furnishes it, at what charge, if any, what voltage and whether direct or alternating current. If a.c., what cycle and phase.

A2.13. Availability of compressed air, pressure, volume and charge, if any.

A2.14. Safe bearing value of soil.

A2.15. Corrosion allowance to be added:

A2.15.1. To parts in contact with water;

A2.15.2. To parts not in contact with water.

A2.16. Safety cages required on ladders, if any.

A2.17. Number and location of pipe connections, and kind and size of pipe to be accommodated.

A2.18. Overflow, stub or to ground, and size of pipe.

A2.19. Is steel to be sand, grit or shot blasted, pickled or otherwise cleaned of mill scale?

A2.20. Kinds of paint or protective coatings and number of coats:

A2.20.1. Inside surfaces;

A2.20.2. Outside surfaces.

A2.21. Specifications for any additional accessories required.

A3. *Information to Be Furnished by Purchaser for a Standpipe or Reservoir:*

A3.1. If a standpipe, capacity and maximum height of water.

A3.2. If a reservoir, capacity and diameter.

A3.3. Roof pitch and projection at eaves (unless the purchaser wishes to leave to the contractor the selection of proper and appropriate dimensions).

A3.4. Type of joint construction, whether riveted or welded, if there is a preference.

A3.5. The desired time for completion.

A3.6. Location of site.

A3.7. Type of road available for access to the site and whether public or private.

A3.8. Type, thickness and kind of support of roof, if required.

A3.9. Name of and distance to nearest town.

A3.10. Name of and distance to nearest railroad siding.

A3.11. Availability of electric power, who furnishes it, at what charge, if any, what voltage and whether direct or alternating current. If a.c., what cycle and phase.

A3.12. Availability of compressed air, pressure, volume, and charge, if any.

A3.13. Safe bearing value of soil.

A3.14. Corrosion allowance to be added:

A3.14.1. To parts in contact with water;

A3.14.2. To parts not in contact with water.

A3.15. Safety cages required on ladders, if any.

A3.16. Number and location of pipe connections and kind and size of pipe to be accommodated.

A3.17. Overflow, stub or to ground, and size of pipe.

A3.18. Is steel to be sand, grit or shot blasted, pickled or otherwise cleaned of mill scale?

A3.19. Kinds of paint or protective coatings and number of coats:

A3.19.1. Inside surfaces;

A3.19.2. Outside surfaces except underside of bottom;

A3.19.3. Underside of bottom.

A3.20. Specifications for any additional accessories required.

A4. *Information to Be Furnished by Bidder for an Elevated Tank:*

A4.1. A drawing showing the dimensions of the tank and tower including the tank diameter, the height to lower and upper capacity levels, the sizes of principal members and the thickness of plates in all parts of the tank and tower. Also, if required by the purchaser, a tabulation showing the rivet data for each type of riveted joint and the welding data for each type of welded joint.

A4.2. The number, names and sizes of all accessories included.

A5. *Information to Be Furnished by Bidder for a Standpipe or Reservoir:*

A5.1. A drawing showing the dimensions of the standpipe or reservoir including the diameter, shell height, and the thickness of plates, the type and thickness of the roof, the thickness of the bottom interior and sketch plates, and the sizes or weights of structural members; also, if required by the purchaser, a tabulation showing the rivet data for each type of riveted joint and the welding data for each type of welded joint.

A5.2. The number, names and sizes of all accessories included.

A6. *Drawings:* After award of a contract, the contractor shall prepare foundation plans and detail drawings, such drawings to be submitted to the purchaser for approval before proceeding with any fabrication. Unless prohibited by the purchaser, the steel may be ordered from the design drawings, and, if any changes in capacity or governing dimensions are made by the purchaser which affect the steel ordered, any loss to the contractor shall be assumed by the purchaser. In the preparation of drawings for welded tanks, standard welding symbols as recommended by the American Welding Society shall be used.

A7. *Cleaning and Shop Painting:* The purchaser shall specify the method of cleaning the steel and the type or make of paint or coating material to be used. The following alternative methods are believed to represent good practice:

A7.1. Plates and structural shapes may be sand, grit or shot blasted, or pickled, to remove the mill scale, after which they shall receive a shop coat of an inhibitive steel primer on all parts except contact surfaces and edges to be welded.

A7.2. Plates and structural shapes may be dehydrated with the oxy-acetylene torch, removing such mill scale as becomes loosened with one application of the torch followed by wire brushing, after which all parts shall be given one coat of inhibitive primer while the parts are still warm, except contact surfaces and edges to be welded.

A7.3. Plates and structural shapes may be fabricated and shipped to the erection site without paint, and then shall be erected and allowed to weather until the mill scale is loosened from both interior and exterior surfaces, after which the steel shall be dried, wire brushed and painted with one coat of an inhibitive steel primer on all surfaces. *Note:* This method may be objectionable because of the possibility of mill scale being carried into the distribution system.

A7.4. If no special cleaning is desired, the steel may be painted with an inhibitive primer directly over the mill rolled surfaces, after removing such rust, loose scale and other foreign material as may be removed by wire brushing. The contact surfaces or welding edges should not be painted.

A8. *Field Painting:* After the tank is completely erected, and after it has been tested, interior and exterior surfaces should be cleaned of dirt, rust or foreign material, the welding edges or rivet heads wire brushed, and any abraded spots and all accessible surfaces which were not painted in the shop shall then be spot coated with the inhibitive primer used in the shop, after which the interior and exterior surfaces shall be given the number of coats of paints of the makes or types and colors specified by the purchaser.

A9. *Kind of Paint:* It is recognized that various types and kinds of paint have in great measure demonstrated their suitability for water works use and that no one type or kind is universally applicable. The following are indicative of what is believed to be best practice at present.

A9.1. *Interior Paint:* All interior surfaces of the tank shall be given one coat of interior first coat paint, either in the shop or in the field.

After erection the first coat, if applied in the shop, shall be retouched and all seams and other surfaces not painted in the shop, shall be painted with the same paint.

After the first inside paint coat has thoroughly dried, all inside surfaces shall be given a coat of inside second coat paint in accordance with the formula in Sec. A10.

A9.2. *Outside Surfaces:* All outside surfaces, including all structural members with the exception of the underneath surface of flat bottoms, shall be given one coat of outside first coat paint in the shop or in the field.

After erection, if the first coat was applied in the shop, it shall be retouched with the same paint covering any abraded spots or surfaces which were not painted in the shop, after which all outside surfaces shall receive a second coat of either outside black paint or outside aluminum paint.

A9.3. *Underside of Flat Tank Bottoms:* The underside of flat tank bottoms shall receive a protective coating in the field. If the bottom is riveted, it shall be coated after it has been tested and while it is on horses. If the bottom is welded, the bottom plates may be coated and, after drying, placed in position on the grade or foundation before being welded. The under surfaces may be painted with black asphalt paint or they may be coated with an approved rust-inhibiting high flash-point grease. In the case of welded bottoms, when the grease coating is used, there shall be placed under each seam and under the shell to bottom connection a strip of asbestos about 6 in. wide which shall be impregnated with the above mentioned rust-inhibiting high flash-point grease.

A10. *Types and Kinds of Paint:* The following paints are suggested as suitable for painting tank structures.

All ingredients of the following paints shall be in accordance with applicable current specifications of the American Society for Testing Materials.

A10.1. *Paint Number 1—Inside First Coat:*

Paste Red Lead	100 lb.
Boiled Linseed Oil	1.625 gal.
Fine Litharge	10 lb.

Beat up the litharge in one quart of boiled oil and add to paint.

Makes about 4.25 gal. of paint.

Paint should be applied without thinning whenever temperatures are high enough to permit thorough, smooth brushing out (about 70° F.). When paint is too thick to brush out smoothly, turpentine may be added, using the minimum amount necessary to secure proper consistency, but in no case to exceed 3 pints of turpentine to 100 lb. of paste red lead. (The above is substantially in compliance with Federal Specifications of the Bureau of Standards TTP-86, adopted September 9, 1939.)

A10.2. *Paint Number 2—Inside Second Coat:*

Same as first with addition of 0.75 lb. of paste lampblack to each batch.

A10.3. *Paint Number 3—Outside First Coat:*

Paste Red Lead	100 lb.
Raw Linseed Oil	2.125 gal.
Drier	1 qt.
Turpentine	1 qt.

Makes about 4.87 gal. of paint.

Note: The above red lead paint formulas are based on paste red lead made by grinding 100 lb. of dry red lead with 8 lb. of linseed oil.

A10.4. *Paint Number 4—Outside Second Coat—Aluminum Finish:*

Pigment—2 lb. Aluminum Paste

Vehicle—1 gal. long oil varnish

The aluminum paste shall comply with the latest revision of A.S.T.M. Specifications D 474 (type A).

Long oil varnish shall comply with the following specifications:

The vehicle shall consist of a long oil varnish, made from ester gum, cumaroneindene, Amberol B1 or F7 or other suitable resins, together with suitable drying oils, and shall fulfill the following requirements:

A10.4.1. The varnish shall be clear and transparent.

A10.4.2. The viscosity shall be between 0.65 and 1.25 poise at 25°C. (77°F.), corresponding to Tubes B to E of the Gardner-Holdt Air Bubble Viscometer.

A10.4.3. The acid number of the vehicle shall be less than 15, based on the non-volatile content of the varnish.

A10.4.4. It shall contain not less than 50 per cent by weight of non-volatile oils and gums.

A10.4.5. It shall pass a 60 per cent Kauri Reduction Test as described in Federal Specification TT–V–81, paragraph F–2g.

A10.4.6. When thoroughly mixed with the aluminum paste specified in the proportion of 2 lb. per gal. of vehicle, the paint shall have good leafing quality, show satisfactory brushing and leveling properties, and shall not break or sag when applied to a vertical, smooth, steel surface.

A10.4.7. The paint shall set to touch in not less than 1 hr. nor more than 6 hr. and dry hard and tough in not more than 24 hr. at a temperature of 20°C. (68°F.) to 30°C. (86°F.).

A10.5. *Paint Number 5—Outside Second Coat—Black Color:*

The paint furnished shall comply with the United States Department of Commerce Circular of the Bureau of Standards, No. 94, U. S. Government Master Specification 14b for ready-mixed paint.

A10.6. *Paint Number 6—Asphalt Varnish for Underneath Surface of Flat Bottoms:*

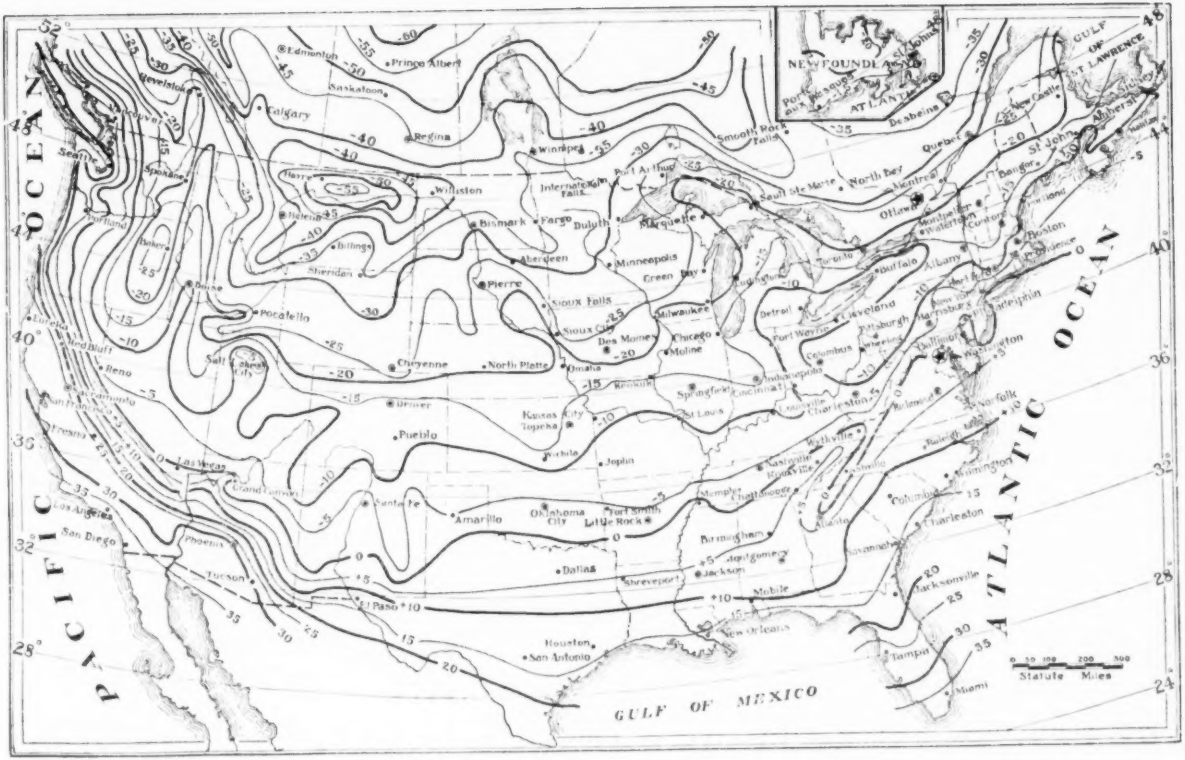
Paint furnished shall comply with U. S. Government Specification for Asphalt Varnish, Federal Specification Board Standard Specification 19, revised January 2, 1923.

A11. *Electric (Cathodic) Protection of Tank Interiors:* The electrolytic method of protecting water tank interiors has proved to be entirely satisfactory when properly installed and maintained. It is, therefore, recommended for the protection of interior tank surfaces except in cold climates where ice may dislodge the electrodes.

A12. *Foundations—General:* The foundations for elevated tank structures are of considerable importance, because any unequal settlement changes considerably distribution of stresses in the structure and may cause leakage or buckling of the plates. The tops shall be located accurately at the proper elevation. The following is recommended practice with regard to foundations.

A13. *By Whom Designed:* The contractor shall furnish foundation plans based on an assumed soil pressure of 4,000 lb. per sq.ft. for usual conditions. If purchaser's soil bearing value is different from 4,000 lb. per sq.ft., special foundations shall be designed jointly by the purchaser and contractor or their representatives, the purchaser to bear the cost of any required field tests. Foundations shall be installed by the purchaser who shall furnish all materials except anchor bolts. The earth around the foundations shall be regraded sufficiently to permit efficient work during erection.

A14. *Soil Bearing Value:* Unless the purchaser has knowledge of the soil at the tank site, he shall conduct suitable tests to determine the character and safe bearing value of the soil and its condition as regards homogene-



Isothermal Lines—Lowest One-Day Mean Temperatures (Compiled from United States Weather Bureau Records up to 1925); reproduced by permission of the Associated Factory Mutual Fire Insurance Companies

ity, freedom from old excavation or fill or faults of any kinds.

The following are average soil bearing values:

A14.1. Quicksand and wet alluvial soils, ½ ton per sq.ft.

A14.2. Soft wet clay or sand, 1 ton per sq.ft.

A14.3. Ordinary clay, dry sand mixed with clay, moderately dry sand or firm dry loam, 2 tons per sq.ft.

A14.4. Compact coarse sand or hard clay or gravel, 3 tons per sq.ft.

A14.5. Hard pan or shale in horizontal layers and dry, 5 tons per sq.ft.

A14.6. Hard rock, 20 tons per sq.ft.

A15. *Riser Foundations:* Foundations for the riser pipe shall be provided with a tunnel of adequate size to accommodate the base ells for the piping specified by the purchaser. The opening shall be covered with a sufficient thickness of concrete either properly reinforced to support the load on the riser pipe bottom, or steel beams may be provided for this purpose. The foundation beneath the tunnel shall be adequately reinforced. The contractor shall furnish plans for the riser foundation.

A16. *Column Foundations:* Column foundations may be of any suitable shape and may be either plain or reinforced. The weight of the pier shall be sufficient to resist the maximum net uplift occurring with the tank empty and wind load as specified in Sec. 3.2 blowing in the direction causing the greatest net uplift on any pier. The weight of earth directly above the base of the pier may be included to resist uplift.

A17. *Concrete Design and Materials:* The design of the concrete foundations, the specifications for the cement and aggregate and the mixing and placing of the aggregate shall be in accordance with the joint code of Building Regulations for Reinforced Concrete, Report of Committee E1 of the American Concrete Institute and Concrete Reinforcing Steel Institute Committee on Engineering Practice.

A18. *Detail Design of Foundations:*

A18.1. *Batter:* For battered columns without bottom struts the axis of column foundations shall have the same batter as the column. For battered columns with bottom struts attached to columns or if piers are tied together and for vertical columns the axis of the foundations shall be vertical.

A18.2. *Height Above Ground:* The tops of the concrete foundations shall be at least 6 in. above the ground.

A18.3. *Minimum Depth:* The minimum depth of foundations shall be determined from the minimum average one-day mean temperature chart, as follows:

For minimum temperatures over 32°F.—3 ft. 0 in.

For minimum temperatures under 32° to and including + 10°F.—3 ft. 6 in.

For minimum temperatures under + 10° to and including — 10°F.—4 ft.

For minimum temperatures under — 10° to and including — 20°F.—4 ft. 6 in.

For minimum temperatures under — 20° to and including — 30°F.—5 ft. 0 in.

For minimum temperatures under — 30° to and including — 40°F.—5 ft. 6 in.

For minimum temperatures under — 40°—6 ft. 0 in.

The above minimum depths refer to the depth of the base below the ground line. They should be increased in localities where soil or other factors are favorable for deep frost penetration.

A19. *Size of Top:* The tops of foundations shall project at least 3 in. beyond the column or riser base plates. The top corners shall either be neatly rounded or finished with suitable bevel.

A20. *Pouring:* The riser and column piers shall each be poured monolithically, without any interruption of sufficient duration to permit the concrete partially to set. If it is necessary to pour piers in more than one pour, a sufficient number of dowels shall be used to transmit all specified loads and horizontal wind load shears.

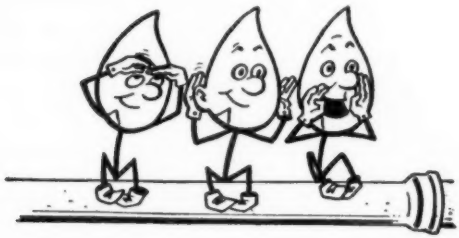
A21. *Finish:* The top portions of piers to a level 6 in. below the proposed ground level shall be finished smooth. Any small holes may be troweled over with mortar as soon as possible after the forms are removed.

A22. *Design of Foundations Without Reinforcement:* Unreinforced piers shall have a vertical portion at the base at least 6 in. in height and shall be designed according to the following allowable unit stresses based on the 28-day compressive strength of the concrete used:

A22.1. Maximum tension in bending, including wind load, 1.5 per cent of 28-day compressive strength.

A22.2. Maximum shear, including wind load, 2 per cent of 28-day compressive strength.

A22.3. Maximum bearing, 20 per cent of 28-day compressive strength for dead and live loads or 25 per cent for dead and live loads combined with wind load.



Percolation and Runoff

Spring, Spring, Beautiful Spring! Oh that it ran dry! Time was when we were swamped with ecstatic evidences of vernal vicissitudes—birds and beasts, bees and flowers as well as young men's fancy, broke out all over in simultaneous bud. Yet now apparently all that remains is a lugubrious lassitude unindicative of any effort at revitalization.

Even our predominantly passionate Parisian observer can give us no more seasonable tidings than a report of the Academy of Medicine's decision that Frenchmen prefer wine because Paris water has "a musty disagreeable odor." And out of supposedly sensuous Spain comes nothing more titillating than a drab description of droughtbound denizens of the Zaragoza region bartering wine for water, quart for quart. Very little more inspiring is the German word from our Dusseldorf harbinger, who reports rejection of a proposal for a public bathhouse in the village of Dassel on the grounds that one 89-year-old resident who had never taken a bath suffered no ill effects from his abstention.

And our domestic mailbag is even less productive of the idyllic wherewithal. A few musty reports too scientific to be human, a plethora of spyitis in the headlines, an uninspiring catastrophe or two, but not a sign of spring. Missing all the homely hints of humanity, missing even the friendly nonsense of an almanac, we now have only the cool columns of a calendar to tell us of the passing of the equinoctial point. *Give us the good old days!*

Good Old Days to the contrary notwithstanding, Secy. Les Jackson and his Southwest Section go-getters aren't letting spring or any unreasonable facsimile thereof get in the way of their go. And what they're going after is the Old Oaken Bucket, which has languished in California ever since that day in June 1939 when the West Coasters came to Atlantic City to claim the trophy, beating out New York's 431 members with a total of 454. As of last February 28, the swashbuckling Sou'westers overhauled the perpetual runner-up New Yorkers with 635 members, and by now have

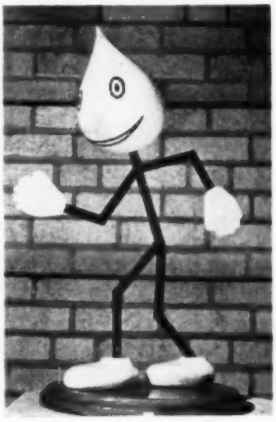
(*Continued on page 2*)

(*Continued from page 1*)

shown them a clean, swift pair of heels in hot pursuit of California's contemporary mark of 767.

The story of the current race is the story mostly of inspirational leadership and of section loyalty, cooperation and hard work; and its milestones are well worth a "point with pride." Beginning back in 1939, the then four-year-old Southwest Section rated an uncomfortable thirteenth in the contest for the new "largest membership" prize, listing a sparse 115 members. By May 1, 1942, the section had inched up to an eleventh-place total of 157, while losing ground to the winning mark of 542. Two years later, in August 1944, a spurt had almost doubled its roster, and its total of 312 earned it a fifth place which represented a bite of 48 members into California's trophy-total lead. The 1946 issue of the A.W.W.A. Directory found the Southwest surge continuing, gaining a 431-member third place in the list of sections and further closing the gap between itself and the leaders' totals of 666 and 570. Still in third place two years later, the Jackson team had managed to gnaw away some more of the lead, so that the score was 738 to 643 to 555. And driving hard since then, they have now ousted New York from second place and threaten California with the claim that they're just beginning to hit their stride.

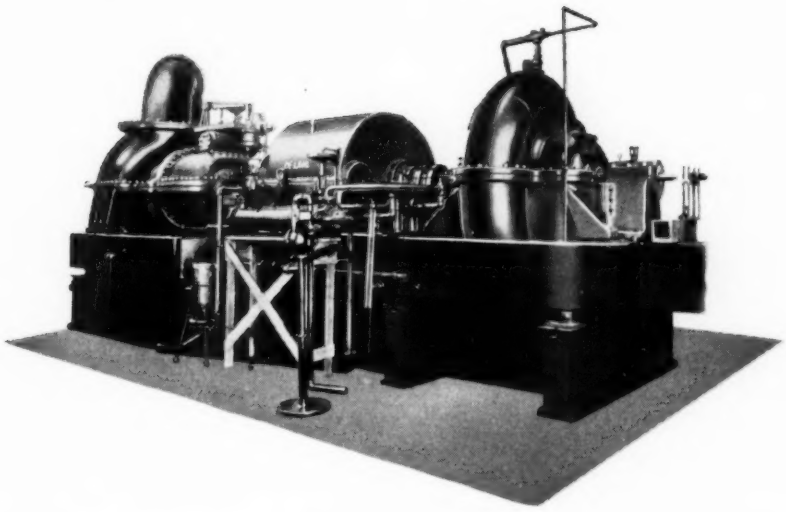
All of which is enough to rouse even us from our spring somnolence and to venture a squint at the "Better New Days," in preference to our lethargic bemoaning of the "old." And roused with us, we hear, are a number of Section secretaries and their membership committees to play the mad hare to the Southwest's supercharged tortoise. What are the odds?



Added inspiration in the Southwest surge, perhaps, has been Willing Water, whose tridimensional embodiment in glass and metal is pictured here. Willie got into the act first as a pancake-thin wooden delegate to the last Southwest Section Meeting, where he perched himself on the registration desk and greeted all registrants. Following his tour of duty there, wooden Willie hopped a freight to the Big City to pay his respects to Harry Jordan, and received such a cordial reception that he decided to stay—with permission after the fact by papa Les Jackson.

Dissatisfied with only two dimensions, Willie soon wanted depth as well as surface, and pampering papa Les got in touch with his filtration plant stork, W. A. Mayhan, who not only delivered the favorite son but made him what he is. Thus, in no time at all, a new and more substantial Willie—with a glass

(*Continued on page 4*)



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TURBINES • HELICAL GEARS • WORM GEAR SPEED REDUCERS • CENTRIFUGAL PUMPS • CENTRIFUGAL BLOWERS AND COMPRESSORS • IMO OIL PUMPS

(*Continued from page 2*)

head, wooden hands and feet, and pipe-stem limbs and torso—was blessed-evented right into New York to take his place beside the thin man. And illustrated here is Willie No. 3, who's happy at home in Little Rock.

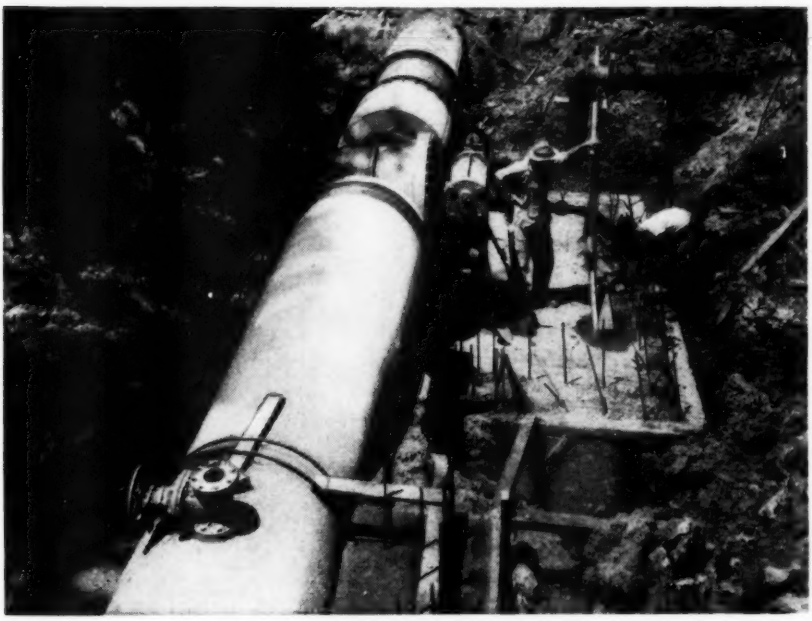
Incidentally, Willie the Second has made his reservations at the Stevens in Chicago for next May 30, have you?

Odorimetry, a subject of our exuberant expatiation of late, has yet another aspect worthy of our note. Thus we take official cognizance of the fact that the gas industry conducts its leak detection investigations by sense of smell and makes sure that smell will tell well by adding odorants to its product when, in its natural form, it is insufficiently odoriferous. As a matter of fact, sufficient stench is supplied to make the escape of gas through household fixtures or open mains immediately obvious to the most unsophisticated human organ of olfaction. Only when his sleuthing must be extended to the miles of buried main does the gasman run into the limitations of his native equipment. And it is at that point that Joe and Ethyl Captan, two bloodhounds trained to track down soil-spoiled whiffs of the mercaptan base chemicals used as odorants, come to the rescue.

Conventionally, the industry has sought its underground leaks by the use of a combustion meter handled by a maintenance crew which follows the line by map, driving holes to the main with a probe bar at 10-ft. intervals, inserting a tube in the hole, and bringing the necessary air-gas samples to the surface with an aspirator. Even supplemented by the clues provided in vegetation surveys, this method has been found time-consuming and expensive, the average crew covering about three city blocks of mains per day. Thus it was that Joe and Ethyl were brought into the picture by C. E. Gill, chemical engineer-owner of the Natural Gas Odorizing Co. of Houston, Tex., to apply their supersensitive sniffers to the task. And, trained by a veteran of the Marine K-9 Corps, the two Captans have proved their ability to nose out more leaks more accurately than the combustion meter and to cover about seven miles of mains per day at costs approximating five dollars per mile.

Now the pure, potable stuff we supply is, of course, odorless as far as we're concerned, but being only human and finding the human nose in iller than ever repute these days, we're willing to bet that even water has a characteristic scent to the well-weaned bloodhound. And who are we to waste our waning funds on complicated scientific apparatus for leak detection when there's a simpler better way. As a matter of fact, we do not doubt that, kept properly thirsty, a Joe and Ethyl of our own could be depended upon to excavate each leaking main as they found it. To the kennels, men—but man those hydrants!

(*Continued on page 6*)



CONCRETE PIPE

. . . the Economy "Champ" for Waterlines

Yes, concrete pipe for waterlines is the champion—any way you look at it. Its first cost is moderate, it lasts a lifetime and its annual cost for upkeep is mighty low. Taken together all these add up to ***low-annual-cost*** waterlines.

Concrete pipe has the structural strength to resist the strain of continuous heavy-duty service. It sustains heavy overburdens; its tight joints and uniformly dense structure prevent leakage. There is no tuberculation and far less incrustation in concrete pipe waterlines to impair their hydraulic capacity; taste, odor and dirty water conditions are minimized.

In the construction of the concrete water main in Kansas City, Mo., shown above, more than 7 miles of large diameter concrete water pipe was used. Samuel Kraus, of St. Louis, was the contractor.

Whether you are planning a large water line like this Kansas City project or a small, local community or industrial job—specify concrete pipe for long life and dependable ***low-annual-cost*** service.

PORTLAND CEMENT ASSOCIATION

33 West Grand Avenue, Chicago 10, Illinois

A national organization to improve and extend the uses of portland cement and concrete . . . through scientific research and engineering field work

(*Continued from page 4*)

Water Pollution Control Advisory Board appointments have been made by President Truman in accordance with the terms of the Water Pollution Control Act of 1948. The board consists of six nongovernment members and five representatives of federal agencies, and is charged with the function of reviewing the policies and program of the U.S.P.H.S. and making recommendations. The nongovernment members, chosen to include an engineering expert, an advocate of wildlife conservation, and representatives of municipal and state government and affected industry, are: N. T. Veatch, Cons. Engr. and A.W.W.A. Past-President; Thomas Berrigan, Director and Chief Engr., Boston Metropolitan Dist. Sewers; Michael Klein, Chief Engr. of New York's Borough of Manhattan; L. A. Danse, chairman of the industrial waste committee of General Motors Corp.; Stanley B. Freeborn, of the University of California College of Agriculture; and Carl D. Shoemaker, Conservation Director for the Wildlife Federation. Government agencies represented on the board are the Federal Works Agency, Departments of the Army, Interior, and Agriculture, and the Fish and Wildlife Service.

The quality of Ohio River water is due to benefit from the activities of the Ohio River Valley Water Sanitation Commission. Requirements for treatment of wastes discharged into the Cincinnati Pool—a 22-mile portion of the river between two navigation dams—will eliminate most suspended solids and reduce B.O.D. by 65 per cent. Public health officials, unanimous in their acceptance of the recommendations, have committed Cincinnati and the adjacent municipalities on the Kentucky side of the pool to conforming, although the requirements exceed the original terms of the Ohio compact and will necessitate changes in plans already drawn for sewage disposal works.

Water level watchers in the thirsty ground water areas of the U.S. may derive some small comfort in knowing that they are not the only of Nature's creations who must dig deep to quench their thirst. Consider the Jarrah tree, a species of eucalyptus native to Australia, which sometimes sends its roots as deep as 120 ft. to obtain its water supply. It is not now known whether the Jarrah will yield to tapping, but that possibility may well be explored if our current drydom persists.

Harvey R. Wilke has joined the staff of Purdue University as associate professor of sanitary engineering, with duties that include teaching, the direction of research projects in water treatment, and participation in extension work in the state of Indiana. For the past three years he was an engineer with the Missouri Division of Health.

(*Continued on page 8*)

WITH Smith tapping equipment you can make branch connections up to 42″ in diameter under pressure to any type or size of pipe, without interrupting service, draining the line, or riling the water. These machines are used with SMITH tapping sleeves, hat flanges, and tapping valves. The entire operation is quick, simple and satisfactory.

Write for further information.

11R

GATE VALVES
CHECK VALVES
FIRE HYDRANTS
INSERTING VALVES
TAPPING SLEEVES AND VALVES
WATER SERVICE BRASS GOODS

THE A. P. SMITH MFG. CO.
ESTABLISHED 1896
EAST ORANGE NEW JERSEY

FLOOR STANDS
INDICATOR POSTS
TAPPING MACHINES
INSERTING MACHINES
PIPE CUTTING MACHINES

(Continued from page 6)

Reports on 1948 construction and cost trends continue to arrive, but some semblance of pattern is already emerging from the welter of at times conflicting statements. It is pretty generally agreed that costs are stabilizing if not actually declining, and that new housing at least has fallen off rather sharply. A survey released by the Associated General Contractors of America is optimistic about the volume of construction expected in 1949, since increases in public works are expected to offset declines in housing construction. *Engineering News-Record* reports that light construction is down but heavy construction booming, with construction activity substantially below last year's marks only in highways and—significantly enough—water works (26 per cent below).

Many materials shortages are easing, although the worst ones still remain. Steel is still critical, although the possibility of a letup is being expressed. Cast-iron pipe, despite fluctuations in production, retains its backlog of unfilled orders, according to the Federal Works Agency and the Construction Division of the Department of Commerce.

About all one can conclude from all this is that the peak of the boom may have passed, but present prospects indicate that the boom itself is still with us.

Fluoridation of their respective water supplies has been authorized by the city councils of Ludington and Albion, Mich. Not content to wait until fluoride addition at such places as Grand Rapids has been investigated over a longer period of time, the city fathers have obtained the cautious consent of their department of health. Despite the introduction of new methods to fight dental caries (*see* December P&R, p. 14), the pressure on the water works does not seem to be slackening.

G. B. Schunke, assistant superintendent of the Seattle water department, died on February 4, 1949. He had been associated with the department for 41 years, and had earned the respect and gratitude of his coworkers and the people he served in that time. As an ardent worker for the advancement of the industry, he was active and will be missed, too, in Northwest Section and Association affairs.

Herbert H. Brown, superintendent of the Milwaukee, Wis., water works, died on January 7, 1949, after an extended illness. He had been serving the city for over 25 years, entering upon the position he held last in 1941. An A.W.W.A. national director from 1940 to 1943, he was also his Section's Fuller Award recipient in 1944.

(Continued on page 10)

IRON REMOVAL

equipment for all water supplies—

Iron is objectionable! The U. S. Public Health Service Drinking Water Standards state that the iron (Fe) and manganese (Mn) content together shall not exceed 0.3 ppm for general household use.

To the pulp and paper mills, tanneries, textile mills, chemical plants and many other industries, a low iron content is a necessity!

You have a specific iron and manganese removal problem! Permutit has the equipment! Permutit's equipment can remove iron by base-exchange, by aeration settling and filtration, or by oxidation through manganese zeolites.

Consult Permutit engineers without obligation! Write to The Permutit Company, Dept. JA-4, 330 West 42nd Street, New York 18, N. Y., or to The Permutit Company of Canada, Ltd., Montreal.

Permutit

FOR 35 YEARS WATER CONDITIONING HEADQUARTERS

(*Continued from page 8*)

Flatbush is fast becoming civilized, and you can thank (or blame) water for the change. The turning point, of course, was June 30, 1947, when New Yorks City's Catskill water supply began to flow through Dodgerland in place of the brackish brew that used to coat the utensils, vocal chords and even souls of the natives of old Gowanus. In the months that have passed, the "moider in de eye" of fervent Flatbushites has already softened to a milder mayhem, which promises eventually to dulcify into a "live and let live" lenity. Patent proof of the new outlook was furnished only the other day, when, on the 31-acre site of the old brackwater reservoir, Brooklyn Borough President John Cashmore broke ground for a 2,600-*elevator*-apartment housing development, to be called Farragut Gardens. Time was when the ill-housed Dodgers would have come foist!

"Best of all things is water," sang Pindar nearly 2,500 years ago, and the line which made an excellent beginning to the first Olympian ode still makes excellent sense today. New uses for this worthy material are still being evolved, and add their demands to the total under which the water supply industry is staggering. Air pollution control, in which heightened interest has been shown since the fatal smog incident at Donora, Pa., employs water in various ways. According to the *Industrial Bulletin* of Arthur D. Little, Inc., the efficiency of a "dry cyclone," in which solid particles are removed from air by centrifugal force, can be increased by addition of a water spray. And in a newer device for precipitating the impurities, jets of water are introduced perpendicularly into a rapidly moving stream of fouled air. The violent acceleration given the water breaks it up into a fine spray, giving optimum contact between dust and water. The resultant mist is then centrifuged out in a cyclone. Electrostatic precipitators are also used, and although they do not employ water as an integral part of the process, the collecting plates must be frequently or even continuously washed. Again, in dealing with particles too small to be affected by the centrifugal action of cyclones, even when sprayed with water, a rather sensational innovation known as sonic agglomeration is used. This process, which uses the obscurely understood action of high intensity sound waves to coagulate the impurities and produce a floc, is often aided by the addition of a water or other spray to increase the concentration of the particles being agglomerated. They can then be built up large enough for a cyclone to handle.

One thing that troubles us, in reviewing these excellent methods for cleansing the air we breathe, is that no mention is made of what is done with the spent water which bears away all the wastes and impurities. Let us hope that those who clean the air prove better housekeepers than to sweep the dust under the rug, or upon their neighbor's doorsteps. Little would be gained if the atmosphere were to be purified at the expense of polluting the streams.

(*Continued on page 12*)

WARREN
Solves Your
PIPE
PROBLEMS

BELL & SPIGOT PIPE •
FLANGE PIPE •
MECHANICAL JOINT PIPE •
FLEXIBLE JOINT PIPE •
SPECIAL CASTINGS •
SHORT BODY BELL & SPIGOT SPECIALS •

Warren Cast Iron Pipe and Fittings can be supplied in all sizes 2" to 84" with all types of joints and in accordance with Standard Specifications. Specify "Warren Pipe" for your next job.

Take advantage of our large stock of non-standard patterns, when in need of special castings to meet your individual requirements.

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WARREN PIPE CO. of MASS.
INC.
75 FEDERAL ST., Boston, Mass.

(*Continued from page 10*)

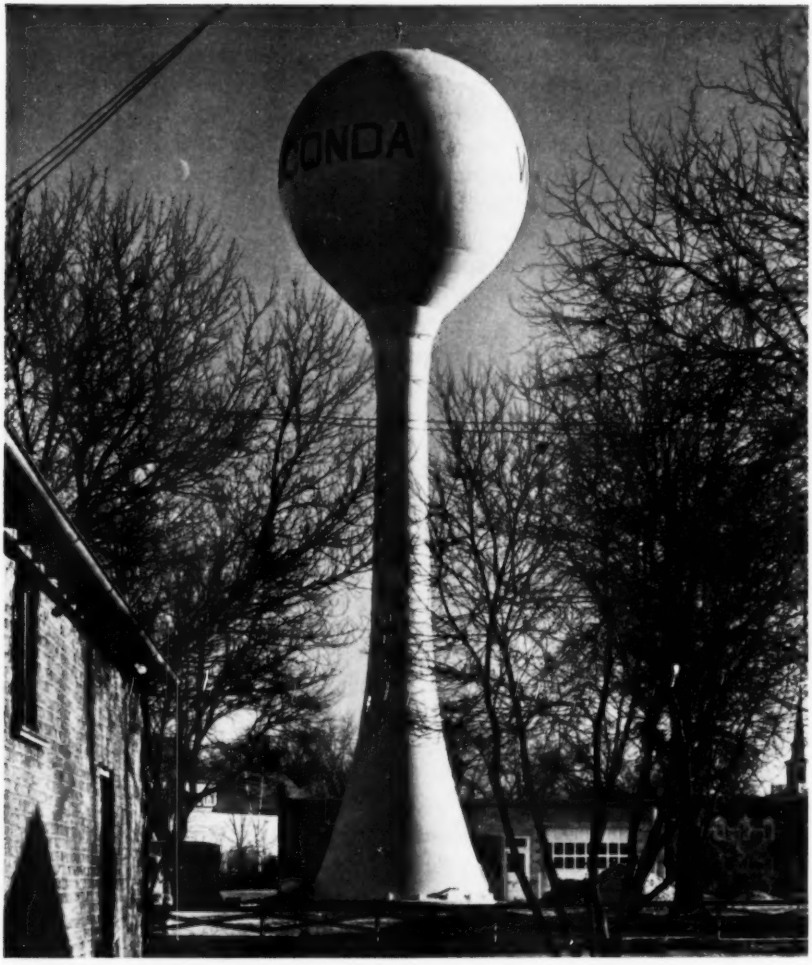
Fishing is one of those sports in which we never progressed beyond the angleworm and bent pin stage, but, inasmuch as it keeps a good many people off our favorite golf course, it's a sport we're more than willing to honor and defend. Thus (though perhaps not entirely thus) have we lent our maximum support to the pollution control program. Thus, too, do we now rise in righteous wrath to protest a newly patented irrigation control system which involves trapping fish and making them work. Pooped out fish can't fight any better than unhealthy or dead ones—and the fight, as we understand it, is the exhilarating part of fishing.

Certain that all fishermen worthy of the name are already enlisted in the campaign to prevent polluting the habitat of their piscatorial playmates, we are certain, too, that they will want to join us in protesting their enslavement by becoming charter members of our sentimental Society for the Emancipation of Frustrated Fish. And to expose the diabolic details of their frustration, we need only point out that the "intermittent irrigation system" involves their subjugation in a treadmill of activity designed to actuate a valve which controls the collection and release of the irrigating water; that is to say, the fish swim into a bucket and by their energy or weight are virtually SimonLegreed into forcing the bucket down to a point where it releases a catch which opens a valve which in turn lets the irrigating water out of a dam, at the same time throwing the fish back into a trap from which they are later released to go through the same routine when the valve again closes, in conjunction with which water is diverted into the bucket, incidental to the production of power when the flow is full, and, by the admission of the inventor, the "system also conserves the water for future operation in between times." Now if it is absolutely necessary for you to know which fish is frustrated before joining the way-above-mentioned society, you may consult U.S. Patent No. 2,345,466 or Inventor S. L. Dias, 610½ E. 3rd St., Bethlehem, Pa., and we assure you that you, too, will spread your fins and come into the fold. Not to dismiss fish too lightly, however, or in this aura of obfuscation, we feel obliged to report two more normally abnormal approaches to the sport:

First is the tale of Chester, Nova Scotia, where residents recently enjoyed the rather unusual experience of picking fish from the trees, thrown there by a nearby mill stream, when the dam broke and loosed an 8-ft. crest of water. Unsporting as was their technique, Chesterites claimed that their methods did not in any way affect the taste of their handicapped adversaries.

And then there is the instance of Inky, mascat of the Indianapolis Water Co., who does his fishing by paw in the screen room of the Fall Creek Pumping Station. Inky, too, prefers his meals to sportsmanship,

(*Continued on page 14*)



Welded Watersphere at Wauconda

The Village of Wauconda, Illinois, installed the 100,000-gallon welded Watersphere shown above to provide gravity water pressure in its water system. The Watersphere is a modern, streamline structure and presents a pleasing appearance.

Write our nearest office for estimates on Waterspheres when making plans for water distribution system improvements.

CHICAGO BRIDGE & IRON COMPANY

BIRMINGHAM CHICAGO TULSA BOSTON SALT LAKE CITY
PHILADELPHIA NEW YORK DETROIT SEATTLE CLEVELAND
SAN FRANCISCO HOUSTON ATLANTA HAVANA LOS ANGELES

(*Continued from page 12*)

and is quite happy to stand alert above the traveling screen, which prevents debris from entering the treatment basin, until a juicy morsel fins by.

We who are content to do even less fish-eating than we do fishing are quite willing to go along with other sportmen in deploring such conscienceless conduct and to claim that "Izaak Walton" would be our middle name if it weren't already "Bobby Jones."

Still another aspect of sport at which we're neither adept nor addicted is duck hunting. Not one of the twenty to twenty-five million ducks killed in the U.S. during a year can name us as its *raison* death. But Nimrod or no, we see eye to eye with the recent Wildlife Conference delegates, duck hunters and all, who feel that pollution of our streams and lakes is a primary menace. That our own reasons concern the hunters more than the hunted should not prevent a cooperative approach to the problem.

Accustomed to a hot seat, Lila Tredwell, switchboard operator for the Halifax Public Service Commission, didn't let a fire faze her when dense, choking smoke from an oakum blaze in the basement began to billow around her desk. While other employees were scurrying for the nearest exit, Miss Tredwell was busy at her post, plugging in her night lines to the maintenance department so that customer trouble calls would get through. Meanwhile the Commission's office manager groped his way back into the building to lead her to safety. All of which shows a devotion to duty almost unexpected these days—and all of which should prove to Halifax water consumers that their interests come first with the Commission.

The Fourth Hydraulic Conference, sponsored by the Iowa Institute of Hydraulic Research, will be held at Iowa City June 12–15. The program will include the presentation of technical papers, a guided tour of the Institute's new facilities, and ample opportunity for informal gatherings.

(*Continued on page 16*)

America's Most Modern Water Works Products

STUART CORPORATION BALTIMORE

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CONVEYORS
PALMER SURFACE WASH SYSTEMS
Model Plants

Contractors of Public Work
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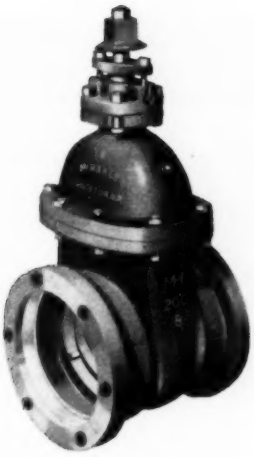

Mechanical Joint VALVES AND HYDRANTS

A.W.W.A. type M&H Valves and Hydrants are now offered with standardized mechanical-joint as adopted by the Cast Iron Pipe Industry. Our mechanical joint valves and hydrants may be used with mechanical joint Cast Iron Pipe without any necessity of special fittings to make installations. This standardized mechanical-joint has a stuffing box into which a gasket is compressed by a Cast Iron gland and bolts. It permits deflection and is a highly successful pipe joint for water mains, gas mains, sewage treatment plants, water filtration plants and practically all kinds of industrial piping.

In standardized mechanical joint, a bolted gland compresses the gasket in a triangular stuffing box.

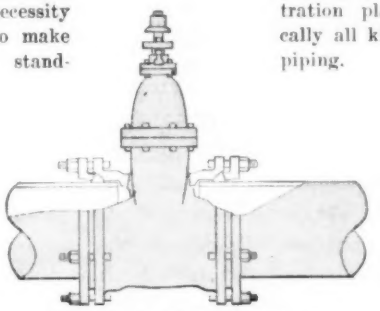

Illustration of how Mechanical-Joint Gate Valve is installed.

Of course, we continue to make M&H Valves and Hydrants with bell-and-spigot, flanged or screwed joints.

M & H PRODUCTS INCLUDE:

FIRE HYDRANTS
GATE VALVES
TAPPING VALVES
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CUTTING-IN TEES

For Water Works Materials Write for Catalog 34

M & H VALVE AND FITTINGS COMPANY

ANNISTON, ALABAMA

For Fire Protection Materials Write for Catalog 40

(*Continued from page 14*)

Alfred O. Norris, general manager of the Birmingham, Ala., Water Works Co. since 1940, has been elected vice-president, general manager and a member of the board of the Indianapolis Water Co. He succeeds Howard S. Morse, previous vice-president and general manager, who has been appointed executive vice-president. Morse, who has been associated with the company since 1925, will continue on the board, but a previous vacancy existed which Norris will now fill.

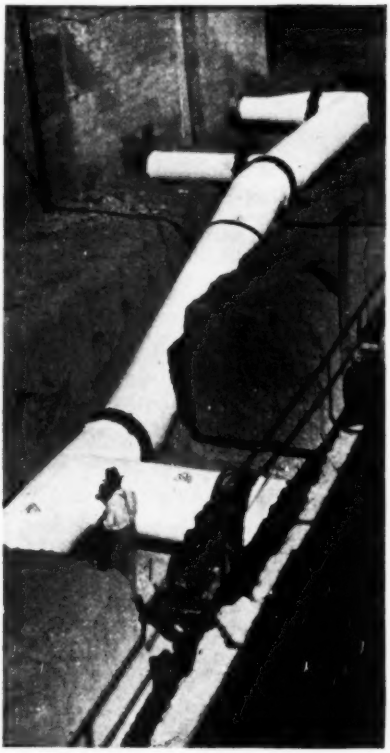
Norris has been associated with the American Water Works Co., of which the Birmingham utility is a subsidiary, since his graduation from Yale in 1924. He worked in water works construction until 1929, when he was transferred to the operating department of the then American Water Works and Electric Co. as assistant to the manager of the water works division's New York Office. In 1936 he was assigned to Cuba as manager of two plants supplying suburban Havana, and also supervised a construction program begun under his management. He joined the Birmingham company in 1940.

News of the discovery of another wonder water should surprise no rabid reader of P&R, but the excitement about the efficacy of Milford, Ohio, water in the treatment of nephrosis, a deadly kidney disease which attacks children, has taken a turn for the worse. Following publicity of the potion in a Cincinnati newspaper column, officials of the village of Milford received requests from all over the country for supplies of the miracle medicament. They, as well as the Jesuit Novitiate at Milford, were generous in shipping it to anyone who asked, with no charge except for the container and postage. Now, however, an enterprising furniture salesman, appropriately named Milford, has seen the light, and asked the village to grant him a year's option on exclusive rights to bottle and sell the supply as "a table and health water," thus placing Milfordites in the position of drawing home brew from their taps and giving them no end of temptation to bootleg the stuff. While the columnist who publicized the water's power cries "crass commercialism," we credit the young Milford with having read *The Song of Bernadette* and made his hero the villainous Mayor, who took the same steps to bottle up the water of Lourdes.

Nonstop around the world in 94 hours and 1 minute makes a big splash in the headlines, but Indianapolis Water Co. customer service employees are no less proud of their 109,484 miles of nonstop service during 1948, nor of their record of 4 miles per hours in traveling the equivalent of more than four times around the world. Nor is the company's automotive division any the less impressed with its own 1948 record of 410,000 miles of water works expeditions. After all, how much further away from home were the Army flyers than the Indianapolis water workers when they finished their trips?

(*Continued on page 18*)

THIS STEEL PIPE
cuts water supply costs



Many waterworks men have found they get improved operating efficiency by using ARMCO Welded Steel Pipe for water supply and force mains.

There is little or no loss from leakage. Strong, tight joints can be made with standard couplings or by field welding. A smooth, spun-enamel lining prevents tuberculation and assures continued high flow capacity.

ARMCO Steel Pipe also has a high strength-to-weight ratio that withstands internal or external pressures. It flexes with the load to guard against explosive bursting due to vibration or sudden overload.

You'll find ARMCO Pipe easy to handle and install. Jobs go fast and costs are low. Diameters of ARMCO Steel Pipe range from 6 to 36 inches with wall thicknesses from 9/64- to 1/2-inch. Write for complete information. Armco Drainage & Metal Products, Inc., 1575 Curtis Street, Middletown, Ohio.

ARMCO

ARMCO WELDED STEEL PIPE

MEETS A. W. W. A. SPECIFICATIONS

(*Continued from page 16*)

The water wagon must have gone the way of the one-horse shay if the data on the liquid consumption of the American public, recently reported in *Chemical & Engineering News*, are to be believed. Appropriately amazed to learn that "the average American drinks each year 55 gal. of coffee, 48 of milk, 19 of beer, 12 of soft drinks and 1¼ of hard liquor," we are yet inclined to doubt that that's the whole story. At least as a chaser for some of that liquor or as a morning-after vehicle for alka-seltzer or aspirin, some water somehow by *someone must be drunk!*

Roberts Hulbert has retired as assistant superintendent of water filtration after 25 years of service to the Detroit department of water supply. Hailed as "the dean of water treatment in Michigan" by the *Michigan Water Works News*, house organ of the state health department, Hulbert received the Fuller Award in 1942.

Another retirement announced by the *News* is that of the oldest filter plant in Michigan, which has served the city of Adrian for 50 years. A new plant, double the size of the old one, is being planned.

(*Continued on page 20*)

GLOSSARY—

Water and Sewage Control Engineering

A Joint Project of the A.W.W.A., A.S.C.E., F.S.W.A. & A.P.H.A.

Approximately 276 pages **Almost 3,000 entries**

If you read, if you write, if you talk or even if you think water works, you need this book! In no other way can you keep the complete terminology of the field at your fingertips. From no other source can you obtain the water works definition of water works terms.

Scheduled to appear in late April, the Glossary has been offered to A.W.W.A. Members at a special price of $1.00 per copy for the paper-bound edition, or $2.00 per copy for the cloth-bound edition, in a special membership mailing dated January 31, 1949.

The needs of nonmembers will be taken care of at a later date at advanced prices, but if you're a member, be sure to reserve your copies now at the special membership price, from:

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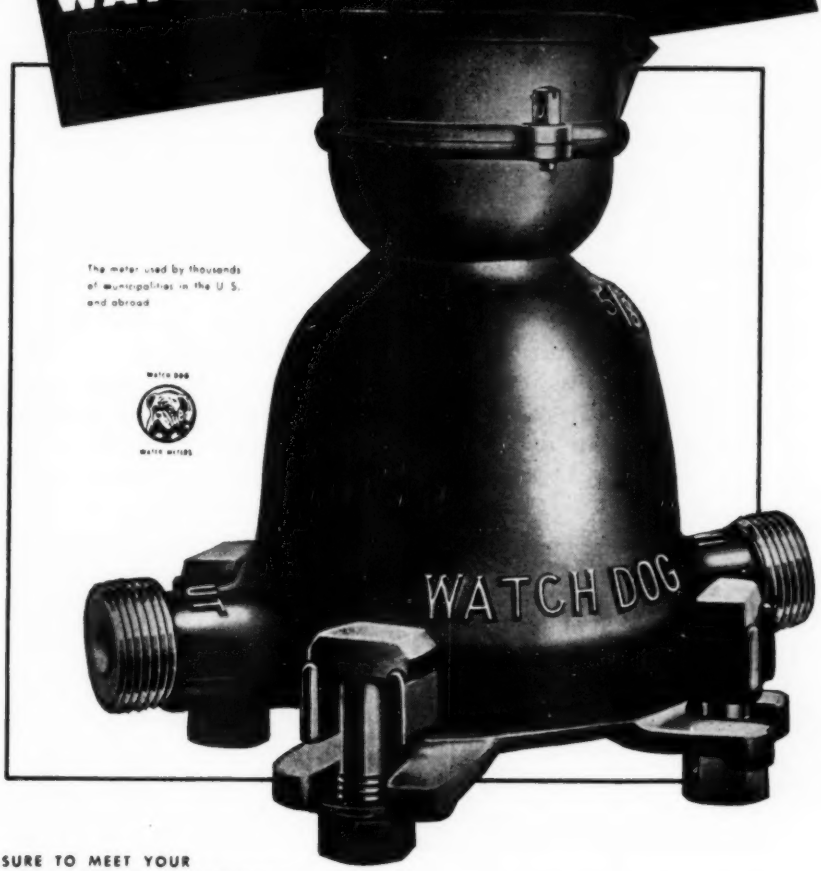
WATCH DOG WATER METERS



SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE

Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States

WATCH DOG WATER METERS

"Watch Dog" models . . . made in standard capacities from 3/8 gpm up; frost-proof and split case in household sizes. Disc type, Turbine type or Compound type. Write for Bulletin.

WORTHINGTON-GAMON METER COMPANY

296 South Street, Newark 5, New Jersey

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PUMP AND MACHINERY CORPORATION

(*Continued from page 18*)

Clifford E. Earls, superintendent and chemist of the St. Augustine, Fla., water softening and purification plant since 1941, has resigned his post to join the White Star Chemical Corp. of Jacksonville, Fla.

Chain Belt Company's Los Angeles district office and warehouse has been moved to new and larger quarters at 3838 Santa Fe Ave., with J. V. MacDonald still in charge as district manager. In addition to the Rex and Baldwin-Rex products available at the location, facilities have been installed for the machining of sprockets, shafting, shaft coupling and other power transmission items.

J. Walter Ackerman, consultant of Munnsville, N.Y., must be holding his head pretty high—and so must Mrs. Ackerman. Now retired, Ackerman has been head of the water departments of Utica and, earlier, Auburn, and is an A.W.W.A. Honorary Member, which is something of a distinction in itself. Parental pride being what it is, however, it is a fair bet that the Ackermans are thinking more of their son's career these days. A West Point graduate and air attache to the U.S. Embassy in London, J. Brevier Ackerman has just been promoted to the rank of brigadier general.

(*Continued on page 22*)

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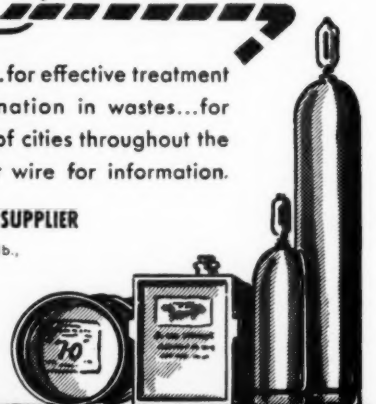

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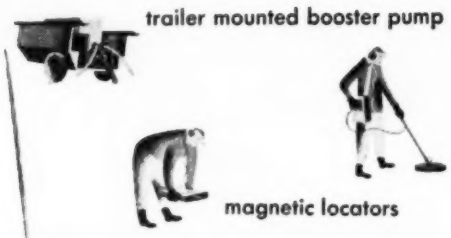

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Anderegg, James A., Student, San. Eng., Massachusetts Inst. of Technology, 64 Westgate, Cambridge 39, Mass. (Jr. M. Jan. '49)

Andres Casco, A., Sr. Student, Civ. Eng., Univ. of Michigan, 1100 E. Huron, Ann Arbor, Mich. (Jr. M. Jan. '49)

Armco Drainage & Metal Products, Inc., Z. O. Riddle, State Mgr., 216 Coosa St., Box 862, Montgomery, Ala. (Assoc. M. Jan. '49)

Averill, Alton W., Maint. Supt., Water Supply, Div. Corps of Engrs., 5900 MacArthur Blvd., Washington 16, D.C. (Jan. '49)

Baker, R. Gail, City Engr., 2019 N. 3rd St., Phoenix, Ariz. (Jan. '49)

Bakkum, Peter L., Student, San. Eng., Georgia Inst. of Technology, 53½ Baker St., N.W., Atlanta, Ga. (Jr. M. Jan. '49)

Barbehenn, E. W., Township Engr., Director of Public Works, 574 Valley St., Maplewood, N.J. (Jan. '49)

Barlow, Willis D., Design Engr., Havens & Emerson, 233 Broadway, New York 7, N.Y. (Jan. '49)

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Barrus, Ben M., Sales Engr., Layne-Atlantic Co., Box 2431, Orlando, Fla. (Jan. '49)

Bartholomew, J. H., Mgr., Atlantic County Water Co., 11 Old Turnpike, Pleasantville, N.J. (Jan. '49)

Beamer, Norman H., Resident Chemist, U.S. Geological Survey, 720 Naval Shipyard, Philadelphia, Pa. (Jan. '49)

Beeth, Gunnar, Civ. Engr., Instituto Nacional de Obras Sanitarias, Dept. de Estudios y Proyectos, Reducto a Glorieta, Caracas, Venezuela (Jr. M. Jan. '49)

Benedict, Paul C., Dist. Engr., U.S. Geological Survey, Water Resources Div., Lincoln, Neb. (Jan. '49)

Berkman, Anton H., Prof. of Biological Sciences, Director of Research Grant 457, Texas College of Mines, El Paso, Tex. (Jan. '49)

Birdsall, Claude W., Civ. Engr., 1700 "F" St., Belmar, N.J. (Jan. '49)

Brown, Gordon D., Supt. of Maint., Board of Water Supply, 4308 Sierra Drive, Honolulu 17, Hawaii (Jan. '49)

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Burke, Thomas, Chief Operating Engr., Bureau of Eng., 1747 N. Springfield Ave., Chicago 47, Ill. (Jan. '49)

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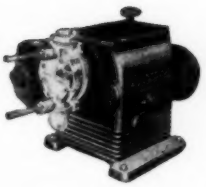

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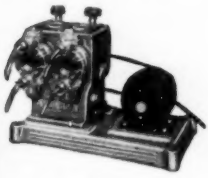

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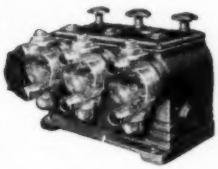

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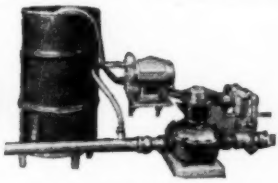

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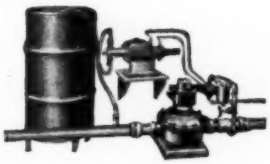

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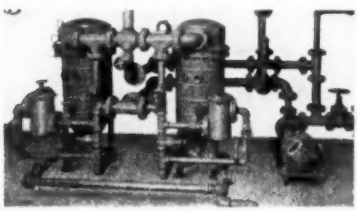

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Doan, R. L., *see* Phillips Petroleum Co.

Dobson, Robert A., Pres., Dobson Bros. Constr. Co., 809 First National Bank, Lincoln, Neb. (Jan. '49)

Doubek, Joseph, Chief Operating Engr., Roseland Pumping Station, 351 W. 104th St., Chicago 48, Ill. (Jan. '49)

(Continued on page 34)

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(*Continued from page 32*)

Eddy, William C., Cons. Engr., Kirkham Eng. Co., 3717 Garfield, Lincoln, Neb. (Jan. '49)

Edelblut, Walter J., Jr., Engr. & Secy., Edelblut Constr. Co., Inc., Box 845, Fort Myers, Fla. (Jan. '49)

Emporia, Town of, L. C. Massey, Supt., Water Works, Emporia, Va. (Corp. M. Jan. '49)

Erwin, Richard B., Chief Operating Engr., Western Ave. Pumping Station, 4933 S. Western Ave., Chicago, Ill. (Jan. '49)

Farquhar, W. C., Refinery Engr., Richfield Oil Corp., Box 787, Wilmington, Calif. (Jan. '49)

Fawcett, A. E., Jr., *see* Texas Water Wells, Inc.

Flack, Carl A., Registrar, Water Dept., 216 City Hall, St. Paul 2, Minn. (Jan. '49)

Gaffney, Patrick J., Chief Operating Engr., Lake View Pumping Station, 742 Montrose Ave., Chicago 13, Ill. (Jan. '49)

Garrett, L. L., Supt. of Distr., Utilities Com., Orlando, Fla. (Jan. '49)

Geisinger, G. L., Vice-Pres. & Chief Engr., Northwest Filter Co., 122 Elliott Ave., W., Seattle 99, Wash. (Jan. '49)

Gibson, William C., Education Div., San. Field Training, School of Public Health, Box 229, Univ. of North Carolina, Chapel Hill, N.C. (Jan. '49)

Gleason, George B., Supervising Hydr. Engr., State Div. of Water Resources, 803 California State Bldg., Los Angeles, Calif. (Jan. '49)

Golden, John M., Chief Operating Engr., 14th St. Pumping Station, 1354 Indiana Ave., Chicago, Ill. (Jan. '49)

Gray, John V., Pres., Sweeney & Gray Co., Inc., 5-43—48th Ave., Long Island City, N.Y. (Jan. '49)

Hammann, William, Jr., Engr., Research Dept., Water Works, City Hall, Milwaukee, Wis. (Jan. '49)

Harrington, Arthur W., Dist. Engr., U.S. Geological Survey, 526 Federal Bldg., Box 948, Albany 1, N.Y. (Jan. '49)

Hart, J. Leslie, Asst. Western Sales Mgr., U.S. Pipe & Foundry Co., 122 S. Michigan Ave., Chicago 3, Ill. (Jan. '49)

Hood, George K., C.P.A., 227 North St., Madison 4, Wis. (Jan. '49)

Horner, Oscar L., Chief Engr., Chicago Ave. Pumping Station, 811 N. Michigan Ave., Chicago 11, Ill. (Jan. '49)

Hosmon, R. T., Supt., Dept. of Public Utilities, 129 Williamson St., Milan, Tenn. (Jan. '49)

Hotchkiss, Glenn R., Asst. to Pres., Texas Water Wells, Inc., 951 McCarty, Houston 15, Tex. (Jan. '49)

Hughes, Fletcher, Supt., Water & Sewer Dept., Box 152, Jacksboro, Tex. (Jan. '49)

Hughston, T. L., *see* McPherson Co., The

Jackson, Howard C., *see* Pulaski, Town of

Jackson, Russell, Vice-Pres. & Mgr., Rust Proofing, Inc., Box 1671, Phoenix, Ariz. (Jan. '49)

Jain, Mallinath, Student, San. Eng., c/o Abel Wolman, Johns Hopkins Univ., Baltimore, Md. (Jan. '49)

Jones, Ray H., Salesman, Kennedy Valve Mfg. Co., 21 Lorraine St., Glen Ridge, N.J. (Jan. '49)

Joyce, Livingston, Acting Borough Engr., Municipal Bldg., Bristol, Pa. (Jan. '49)

Kerby, Homer A., Chief Engr., City Utilities, 308 E. Berry St., Fort Wayne 2, Ind. (Jan. '49)

Klaffke, Kenneth, Cons. Engr., 2906 Classen Blvd., Oklahoma City 6, Okla. (Jan. '49)

Koons, Melvin E., Director, Div. of Labs., State Dept. of Health, Box C, University Station, Grand Forks, N.D. (Jan. '49)

Kotz, Samuel E., Public Health Engr., State Dept. of Health, 1255 Carr St., Lakewood, Colo. (Jan. '49)

Krasauskas, John W., Bacteriologist, Dept. of Army, Water Supply Div., 5900 MacArthur Blvd., N.W., Washington 16, D.C. (Jan. '49)

Lambert, Jack, Supt., Public Utilities Com., Mill St., Acton, Ont. (Jan. '49)

Little, Frank S., Water Plant Operator, Utilities Com., 1731 Oakmont St., Orlando, Fla. (Jan. '49)

Lucy, Thomas A., Cons. Engr., 144 East Drive, Baton Rouge 12, La. (Jan. '49)

McDonough, John J., Chief Operating Engr., City Water Dept., 2260 S. Ashland Ave., Chicago, Ill. (Jan. '49)

(*Continued on page 36*)

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(*Continued from page 34*)

McHugh, B. M., City Engr., Supt. of Utilities, Renton, Wash. (Jan. '49)

McPherson Co., The, T. L. Hughston, 408 S. Main St., Greenville, S.C. (Corp. M. Jan. '49)

Massey, L. C., *see* Emporia, Town of

Mejias, Manuel Fernando, Engr., Instituto Nacional de Obras Sanitarias, Qta. Antonieta, Av. San Cosco, La Florida, Caracas, Venezuela (Jan. '49)

Menocal, Serafin, Div. Mgr., Cia. Cubana de Electricidad, Box 200, Camaguey, Cuba (Jan. '49)

Myatt, Guy R., Foreman, City Water Dept., City Hall, Olympia, Wash. (Jan. '49)

Newman, O. P., Secy., Boise Water Corp., Boise, Idaho (Jan. '49)

O'Connell, Ray J., Chief Engr., Central Park Pumping Station, 1015 S. Central Park Ave., Chicago 24, Illinois (Jan. '49)

O'Connor, Charles B., Chief Operating Engr., 68th St. Pumping Station, 6801 Oglesby Ave., Chicago 49, Ill. (Jan. '49)

Okun, Daniel A., Assoc. Engr., Malcolm Pirnie Engrs., 25 W. 43rd St., New York 18, N.Y. (Jan. '49)

Pearce, James M., Chemist, Univ. of Florida, 428 S. Orange, Gainesville, Fla. (Jan. '49)

Pearson, Erman A., Research Assoc., Civ. & San. Eng., Massachusetts Inst. of Technology, Cambridge, Mass. (Jan. '49)

Phillips Petroleum Co., R. L. Doan, Research Dept. Library, Bartlesville, Okla. (Corp. M. Jan. '49)

Phoenix, K. G., Supt., Public Utilities Com., West Lorne, Ont. (Jan. '49)

Piotet Corp., Valfredo Segre, Vice-Pres., 122 E. 58th St., New York, N.Y. (Corp. M. Jan. '49)

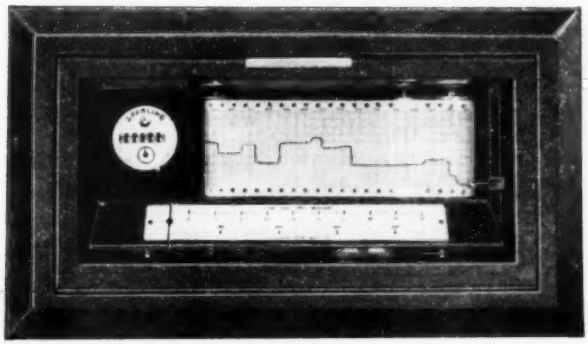
Plank, Raymond I., *see* Catskill Board of Water Com.

Pruden, Albert P., Repairman, Water Service, Water Dept., 44 Phoenix Ave., Morristown, N.J. (Jan. '49)

Pryor, Orval W., Water Foreman, Munic. Utilities, 514 Cimaron Ave., La Junta, Colo. (Jan. '49)

(*Continued on page 38*)

SPARLING MAIN-LINE METERS



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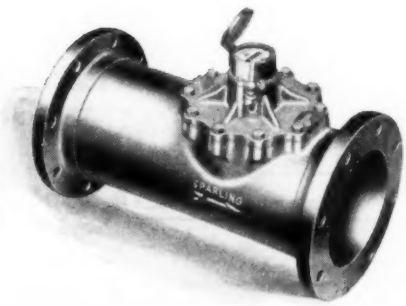

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622 Broadway.....CINCINNATI 2
101 Park Avenue.....NEW YORK 17
1932 First Avenue.....SEATTLE 1
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(*Continued from page 36*)

Pulaski, Town of, Howard C. Jackson, Supt., Water Dept., Box 150, Pulaski, Va. (Corp. M. Jan. '49)

Purdie, David J., Dist. Mgr., Builders Iron Foundry, 75 Personette Ave., Verona, N.J. (Jan. '49)

Resnik, George A., Chem. Engr., Industrial Chemicals, Inc., 2215 S. Main St., South Bend 14, Ind. (Jan. '49)

Reynolds, Preston A., Public Utility Rate Analyst, George K. Hood, C.P.A., 227 North St., Madison 4, Wis. (Jan. '49)

Riddle, Z. O., *see* Armco Drainage & Metal Products, Inc.

Robb, Carroll E., Civ. Engr., Washington Aqueduct, 1st & Douglas Sts., N.W., Washington 25, D.C. (Jan. '49)

Robinson, W. H., Chief Chemist, G. F. Sterne & Son, Ltd., Brantford, Ont. (Jan. '49)

Schulz, William H., Chief Operating Engr., Cermak Pumping Station, 735 W. Harrison St., Chicago 7, Ill. (Jan. '49)

Segre, Valfredo, *see* Piotet Corp.

Senesy, John J., Engr., Senesy & Van Nest, Box 311, Bound Brook, N.J. (Jan. '49)

Smith, John C., Chief, Operations Branch, Water Supply Div., Corps of Engrs., Washington Dist., 1st & Douglas Sts., Washington 25, D.C. (Jan. '49)

Spencer, T. F., Water Works Supt., City Water Dept., Box 158, Clinton, Miss. (Jan. '49)

Spinnler, Robert, Professional Engr. & Land Surveyor, Elbow Bldg., 115 Market St., Paterson 1, N.J. (Jan. '49)

Stockstill, H. P., Supt., City Water Dept., Box 233, Brandon, Miss. (Jan. '49)

Stone, J. W. L., Dist. Mgr., Peerless Pump Div., 4330 Leavenworth St., Omaha 5, Neb. (Jan. '49)

Stovall, George B., Supt., Water Works, Tide Water Power Co., Morehead City, N.C. (Jan. '49)

(*Continued on page 40*)

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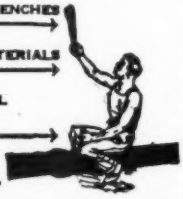

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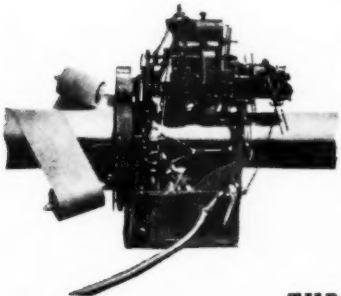

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(*Continued from page 38*)

Texas Water Wells, Inc., A. E. Fawcett Jr., Pres. & Gen. Mgr., 951 McCarty, Houston 15, Tex. (Assoc. M. Jan. '49)

Tom, Albert Q. Y., Research Assoc., San. Eng. Dept., Massachusetts Inst. of Technology, Cambridge, Mass. (Jr. M. Jan. '49)

Tyus, B. H., Chief Engr., Water, Light & Power Dept., 704 S. 7th Ave., Teague, Tex. (Jan. '49)

Underhill, Charles F., Chief Operator & Chemist, Utilities Com., Orlando, Fla. (Jan. '49)

Waite, Robert F., Engr., Tested Appliance Co., 2627 W. 19th St., Chicago 8, Ill. (Jan. '49)

Walter, Lawrence G., Head, Maint. Sec., Water Supply Div., Dalecarlia Filter Plant, 5900 MacArthur Blvd., Washington 16, D.C. (Jan. '49)

Ward, Paul C., Sr. San. Engr., State Dept. of Public Health, 787 Vincente Ave., Berkeley 7, Calif. (Jan. '49)

Watt, D. M., Constr. Engr., Dist. of Columbia Water Supply, 6200 Kilmer St., Cheverly, Hyattsville, Md. (Jan. '49)

Weickert, Ervin C., Civ. Engr. II, Water Works, Constr. Div., 401 City Hall, Milwaukee, Wis. (Jan. '49)

Wood, David A., Sales Engr., Alan A. Wood, 930 Dupont Circle Bldg., Washington, D.C. (Jan. '49)

Work, G. T., Branch Mgr., Worthington Pump & Machinery Corp., 1127 W O W Bldg., Omaha, Neb. (Jan. '49)

Wright, John D., 140 Glenn Pl., Lexington, Ky. (Jan. '49)

REINSTATEMENTS

de Brito, Francisco Saturnino, Jr., San. Engr., Caixa 1631, Rio de Janeiro, Brazil (May '30) *PR*

Diehl, F. D., Supt., Water & Elec. Dept., 111 S. Main St., McPherson, Kan. (Jan. '45)

Eyler, Edward R., Sales Engr., 12 Mayflower Court, Baltimore 8, Md. (Jan. '45) *MP*

Ihling, Herbert M., Field Engr., Water Works, 401 City Hall, Milwaukee, Wis. (Jan. '40)

Maguire, John Joseph, Chief Engr., Montevideo Waterworks Co., Ltd., Zabala 1395, Montevideo, Uruguay (Apr. '29)

Mayer, Max A., Supt. of Repairs & Utilities, San Jacinto Ordnance Depot, Victoria, Tex. (Jan. '46) *MP*

Mence, Harry F., Supt., Water Dept., 134 Main St., Nyack, N.Y. (July '38)

Nelson, Oscar William, Chief Clerk, Water Works, Sioux City, Iowa (Apr. '46)

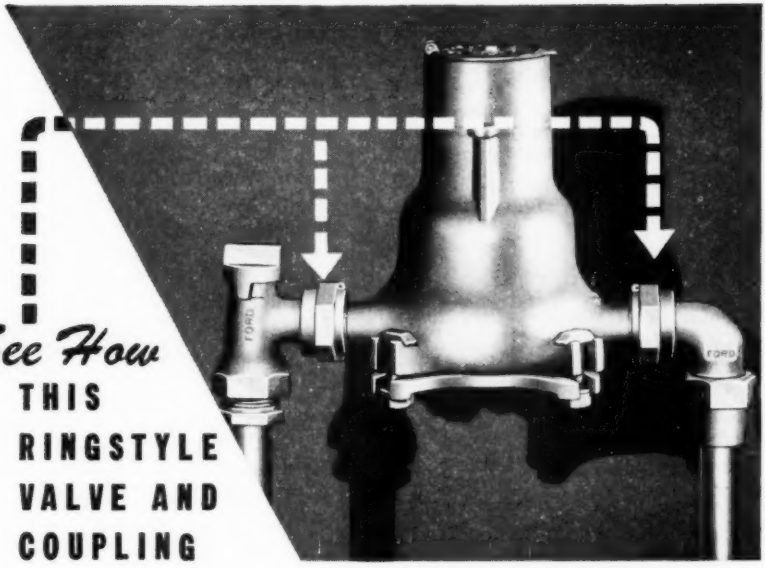
Rausch, Clair C., Sr. San. Chemist, Dept. of Water Supply, Filtration Plant, Water Works Plant, Detroit 14, Mich. (July '38)

Ritchie, R. E., Supt., Water Dept., Harbor Beach, Mich. (Apr. '44)

Schleicher, William A., Chemist, Dept. of Conservation, Game & Fish Div., Frankfort, Ky. (Affil. Oct. '45) *P*

Whitfield, Leonard F., Chief Chemist, St. Clair Processing Corp., Ltd., Sarnia, Ont. (Apr. '46) *P*

(*Continued on page 42*)



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LOSSES

Deaths

Duncan, D. L., Engr., California State R.R. Com., 368 State Bldg., San Francisco, Calif. (Aug. '30)

Schunke, G. B., Asst. Supt., Water Dept., 323 County-City Bldg., Seattle 4, Wash. (Jan. '29) *Director '44. M*

Resignations

Glauber Brass Mfg. Co., The, Kinsman, Ohio (Assoc. M. May '14)

Helton, Glenn, Water Works Dept., Gravette, Ark. (Apr. '48)

Hough, L. E., City Engr., 113 Chicago Ave., Aberdeen, Wash. (Apr. '48)

Houston Utilities Dept., Frank N. Baldwin, Director, City Hall, Houston 2, Tex. (Corp. M. Sept. '34) *MR*

Miller, Paul E., Supervising Chemist, Harmon Color Co., 550 Belmont Ave., Haledon, N.J. (Jan. '39) *P*

Plank, Raymond I., Supt., Board of Water Comrs., 422 Main St., Catskill, N.Y. (Jan. '46) *MP*

Wilkins, Gerald D., City Mgr., 130 W. 6th St., Newton, Kan. (Jan. '48)

CHANGES IN ADDRESS

Changes received between February 5 and March 5, 1949

Adams, Walter F., City Engr., 1626 Bryden Lane, Santa Rosa, Calif. (Oct. '39)

Arbuthnot, James B., c/o World Health Organization, Box 1477, Addis Ababa, Ethiopia (Oct. '46) *P*

Backflow Eng. & Equipment Co., Frank Carlton, 5725 Alcoa Ave., Los Angeles 11, Calif. (Assoc. M. July '39)

Beckman, Wallace J., Gannett Fleming Corddry & Carpenter, Inc., 600 N. 2nd St., Harrisburg, Pa. (Jr. M. Apr. '47)

Bowelle, Bert, 217 Foster Rd., Kennewick, Wash. (Jan. '48)

Boyer, Bruce R., City Engr., City Hall, Cloquet, Minn. (Jan. '47)

Bradlee, Warren R., Civ. & San. Engr., Ford, Bacon & Davis, Inc., Box 5254, Chicago 80, Ill. (Apr. '47)

Breitkreutz, Emil W., 1404 Wilson Ave., San Marino 9, Calif. (Oct. '29) *M*

Broach, Homer H., Headquarters 8th Army, Eng. Sec., APO 343, c/o Postmaster, San Francisco, Calif. (Apr. '46) *MP*

Brown, Wade Gillies, 1317 Arnette Ave., Durham, N.C. (Apr. '43) *MP*

Bubbis, Nathan S., Acting Gen. Mgr., Greater Winnipeg Water Dist., 185 King St., Winnipeg, Man. (Jan. '45) *MP*

Carlton, Frank, Backflow Eng. & Equipment Co., 5725 Alcoa Ave., Los Angeles 11, Calif. (Oct. '39)

Caster, Arthur D., San. Engr., 199 E. Weber Rd., Columbus 2, Ohio (Jan. '42) *MP*

Christenson, C. W., 4081-A Ridgeway Drive, Los Alamos, N.M. (Jan. '47)

Cissna, George W., Southwest Mgr., Neptune Meter Co., 2014 Commerce St., Dallas, Tex. (July '35)

Classen, Ashley G., Cons. Engr., 504 N. Kansas St., Box 58, El Paso, Tex. (Jan. '36)

Cordle, Thomas Llewellin, Cons. Engr., 406 S. King St., Morganton, N.C. (Jan. '43) *MP*

Crabbe, Ben F., 1223½ Orange Ave., Orlando, Fla. (July '35)

DeHaven, Edward, Branch Mgr., Culligan Zeolite Co., 527—2nd Ave., S., Minneapolis, Minn. (Apr. '47)

Dickson, Ross C., Mgr., Peoples Water Service Co., Box 4777, Warrington, Fla. (Jan. '49)

Dowlin, M. R., Sr. Officer, Bureau of Prisons, 6409 S. Warner St., Tacoma 9, Wash. (Jan. '44) *P*

Earls, Clifford Elliott, c/o White Star Chemical Co., 2030 E. Adams St., Jacksonville, Fla. (Oct. '43) *P*

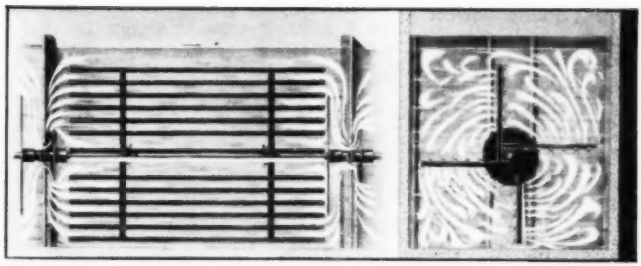
Edling, John O., Supt., Gas & Water Dept., 33 Centre Ave., Schuylkill Haven, Pa. (Jan. '42) *M*

Eisenhauer, W. K., Asst. Supt., Water Dept., 314 W. Liberty St., Vermillion, Ohio (July '46)

Erskine, Harlan M., Dist. Engr., U.S. Geological Survey, Surface Water Resources, Box 750, Bismarck, N.D. (Oct. '46) *R*

(Continued on page 44)

REX *flocculation* EQUIPMENT



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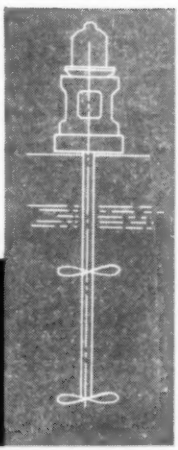

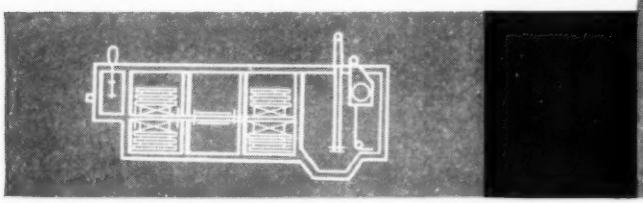

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(Continued from page 42)

Espinosa, Roberto, Civ. Engr., Apdo. Aereo 4583, Bogota, Colombia (Jan. '46)

Everett, W. J., Box 1715, Havana, Cuba (Jan. '41)

Fitch, Reamy C., Box 2104, Dallas 1, Tex. (July '47) *P*

Garrett, M. Truett, Sr., Pres., Garrett Eng. Co., 5008 Almeda St., Houston 4, Tex. (Oct. '46)

Gibson, W. B., 311 Consolidated Bldg., Jacksonville, Fla. (Oct. '37) *Fuller Award '42. Director '45–'46.*

Glidden, A. Leland, Ranney Water Collector Corp., Verde River Ranch, Pauldin, Ariz. (July '35)

Gram, A. L., Bowles Hall, Univ. of California, Berkeley, Calif. (Jan. '37) *MP*

Grant, Howard L., Vice-Pres., Garrett Eng. Co., 5008 Almeda St., Houston 4, Tex. (Apr. '46) *P*

Green, A. Rice, Hydr. Engr., 1104 Hazel St., Charlottesville, Va. (Jan. '46)

Hall, John D., 320 Chemung St., Waverly, N.Y. (Oct. '37) *MP*

Hall, Ronald S., Pres., Hall & Co., Inc., 1 Grove St., Delmar, N.Y. (Apr. '43) *PR*

Hamelin, Douglas Franklin, 1329—9th St., N.W., Calgary, Alta. (Jan. '45) *R*

Hartmann, F. W., Cummins Engine Co., 8 S. Michigan Ave., Chicago, Ill. (July '25) *MR*

Hedgepeth, L. L., 280 Chestnut St., Bound Brook, N.J. (Aug. '29) *Fuller Award '44. PR*

Heiney, J. W., Asst. Div. Mgr., Water Works Service Co., Inc., 50 Broad St., New York 4, N.Y. (Oct. '46)

Heller, Austin, The Barrett Div., Allied Chemical & Dye Corp., 40 Rector St., New York 6, N.Y. (Jan. '43) *MP*

Hidalgo, Armando A., Div. of San. Eng., Caracas, Venezuela (Jr. M. Oct. '48)

Hoffman, M. F., Hotel Hayward, 60 Spring St., Los Angeles, Calif. (Oct. '34) *Fuller Award '41.*

(Continued on page 46)

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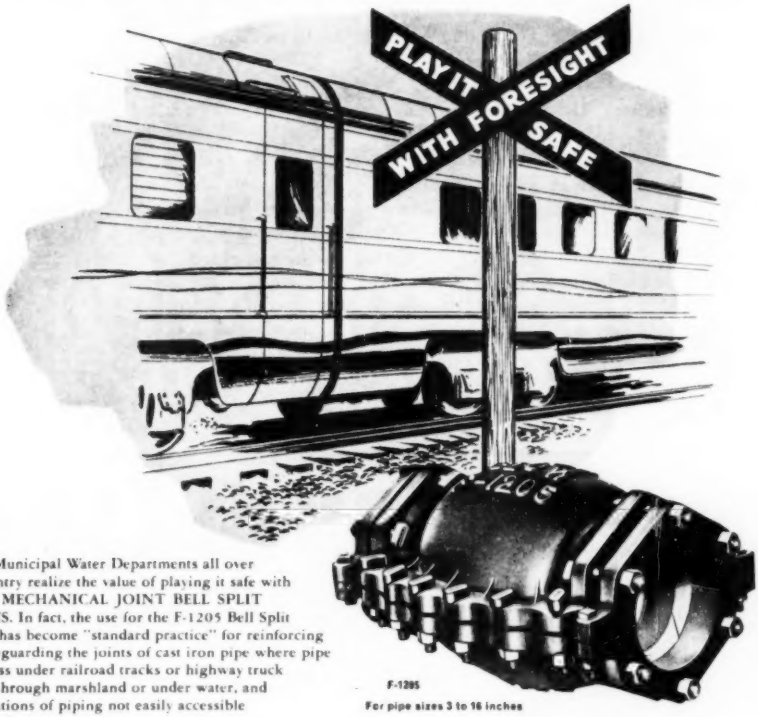

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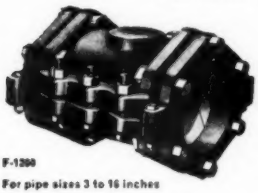

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Hurst, William Donald, Chairman of Comrs., Greater Winnipeg Water Dist., 185 King St., Winnipeg, Man. (Apr. '34) *Fuller Award '46. MP*

Jones, Hugh, Engr., Alex Robertson Co., 14433 S. Paramount Blvd., Paramount, Calif. (Jan. '47)

Kegebein, John F., Jr., 617 De Kalb St., Norristown, Pa. (Apr. '41) *MP*

Lanigan, R. L., Asst. Supt., Water Works, Anheuser-Busch, Inc., 721 Pestalozzi St., St. Louis 18, Mo. (Apr. '46) *P*

Larkin, William H., Dist. San. Engr., State Dept. of Health, 21 N. Broadway, White Plains, N.Y. (Apr. '30) *PR*

Lauramore, Horace H., Salesman, Johns-Manville Sales Corp., 311 Consolidated Bldg., Jacksonville 2, Fla. (Oct. '42)

Lysons, Edward, Supt., Water Dept., 53 Cedar St., Snohomish, Wash. (July '40) *M*

Marks, Henry C., 2 Mitchell Pl., Glen Ridge, N.J. (Jan. '44) *P*

Marzec, Edmund J., Board of Health, Gary, Ind. (Jan. '36) *P*

Mau, Gordon E., Eng. Div., State Health Dept., Des Moines 19, Iowa (July '43) *P*

McConnell, Alfred F., 601 S. 1st St., Waco, Tex. (Jan. '48)

McEntee, Harry E., Water Works Engr., 222 Riverside Drive, Mt. Clemens, Mich. (July '38)

McGauhey, P. H., 3940 Welland Ave., Los Angeles 43, Calif. (July '38) *P*

McGrann, John H., Box 55, Station C, Cincinnati 26, Ohio (Jan. '41)

Meleyco, Victor N., 2534 Brewster Ave., Redwood City, Calif. (Jan. '48)

Messer, Richard, San. Engr., State Dept. of Health, 713 State Office Bldg., Richmond, Va. (Sept. '11) *Director '43–'46. Fuller Award '45. P*

(Continued on page 48)

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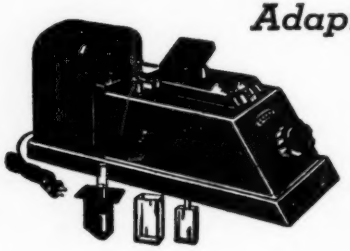

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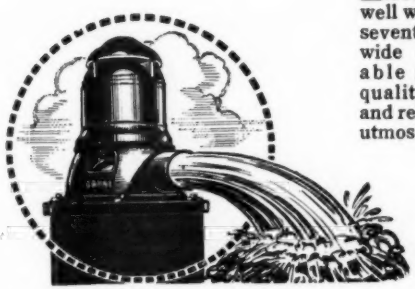

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(*Continued from page 46*)

Morrison, James E., City Mgr., 420 N. Pearl St., Ellensburg, Wash. (Oct. '39) *MPR*

Murphy, Alvin R., Jr., 1st & Lake Silver Drive, Winter Haven, Fla. (Oct. '47) *MPR*

Ogden, Willis L., Yeoman Bros. Co., 939 W. North Ave., Chicago, Ill. (Nov. '43) *P*

Ohio Salt Co., The, Thomas E. Driskell, Water Service Engr., 580 E. Town St., Columbus 15, Ohio (Assoc. M. Oct. '37)

Osthoff, Richard H. L., Jr., Civ. Engr., U.S. Engr. Office, 160 Larch Ave., Bogota, N.J. (Oct. '46)

Parks, James A., 310 W. 34th St., Vancouver, Wash. (Oct. '35) *P*

Perryman, Jon W., Jr., City Mgr., Paris, Tex. (Apr. '48)

Prehn, Louis E., Supt., Water Works, 38 Lathrop Ave., Forest Park, Ill. (July '44)

Ranney Water Installations, Norman B. Courteney, Box 5840, Los Angeles 55, Calif. (Assoc. M. Jan. '49)

Reed, Allen M., Chemist, Electric Auto-Lite Co., Lockland, Ohio (Apr. '44) *P*

Reinicker, L. T., Water Works Service Co., 50 Broad St., New York 4, N.Y. (June '29)

Richards, Robert B., 3043—77th Court, Elmwood Park, Ill. (Jan. '43) *MPR*

Richardson, E. W., Engr., First Narrows Bridge Co., Ltd., Box 3, Hollyburn P.O., West Vancouver, B.C. (Apr. '41) *M*

Ripley, H. A., Ripley & Assoc., Cons. Engrs., 5 Mortlake Block, Edmonton, Alta. (Oct. '44)

Rusta Restor Div., Harco Corp., Russell Stambaugh, 2156 E. 4th St., Cleveland 15, Ohio (Assoc. M. July '40)

Ryan, Edward T., Sales Engr., Ryan Hydraulic Specialties Co., Title & Trust Bldg., Phoenix, Ariz. (July '48)

Sanborn, James F., Framingham Centre, Mass. (Aug. '21)

Satterwhite, Troy L., 609 Gresham Ave., Baytown, Tex. (Jan. '46) *MP*

Schwarz, George M., 985 N. Capitol St., Salem, Ore. (Jan. '47)

Scott, Walter Moffat, 188 Montrose St., River Heights, Winnipeg, Man. (Mar. '14) *Fuller Award '41.*

Simpson, Clyde W., Vice-Pres. & Gen. Mgr., Water Works Equipment Co., 149 W. 2nd South St., Salt Lake City 1, Utah (Apr. '48)

Slater, L. N., Vice-Pres., Consolidated Western Steel Corp. [Los Angeles], Box 2015 Terminal Annex, Los Angeles 54, Calif. (Sept. '31)

Sloan, Garrett, 901 Watkins St., Richmond 22, Va. (Apr. '42) *PR*

Stitt, L. W., Jr., c/o Rheem Mfg. Co., 1025 Lockwood Drive, Houston, Tex. (Jan. '46) *P*

Stockman, R. L., 3215—37th Pl., Seattle 44, Wash. (Oct. '47)

Stone, Wyman R., Chief of Party, Instituto Nacional de Obras Sanitarias, Apdo. 23-Bis, Mexico, D.F., Mex. (Jan. '38)

Tetzlaff, Frank, 1362 Wayne Ave., N.E., Atlanta, Ga. (Jan. '36) *P*

Thompson, E. A., Town Mgr. & Engr., Sackville, N.B. (Jan. '48) *MPR*

Thompson, Ralph F., Chief Chemist, Chemical Eng. Co., 2800 Logan St., Dallas 1, Tex. (Jan. '48) *PR*

Truman, Chester A., Water Dept., 1118 N. Hancock, Colorado Springs, Colo. (Dec. '26) *Director '37–'40. Fuller Award '45. M*

Van Der Lely, J., Alvin Hotel, Tulsa, Okla. (Jan. '49)

Waldron, John T., Dist. Mgr., Calgon, Inc., 2116 Cherry Ave., Huntington, W.Va. (Jan. '46)

Walker Process Equipment, Inc., J. D. Walker, Pres., 518 Hankes Ave., Aurora, Ill. (Assoc. M. Jan. '47)

Whisler, J. H., Engr., S. Morgan Smith Co., 20 N. Wacker Drive, Chicago, Ill. (Jan. '48)

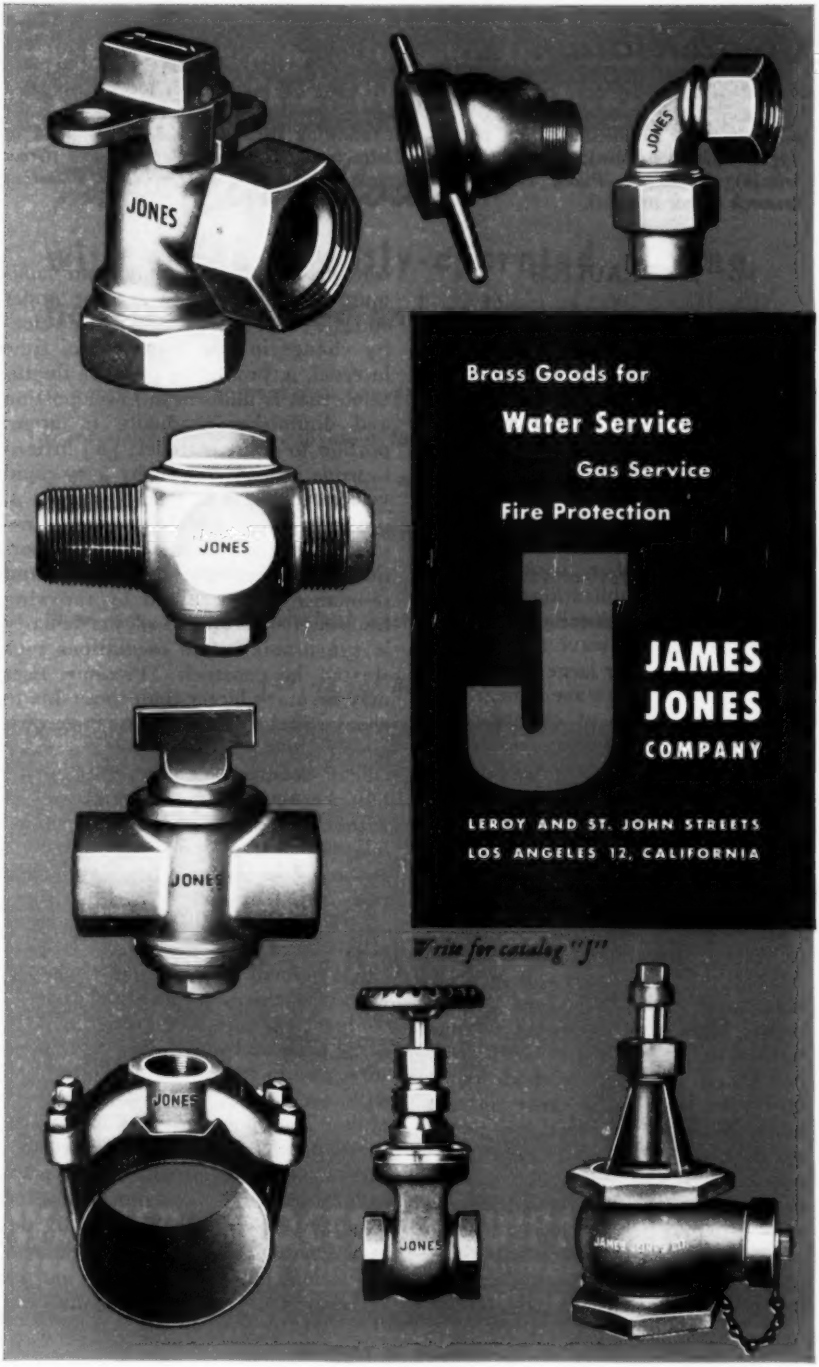
Wiley, John S., U.S. Public Health Service, Environmental Health Center, 1014 Broadway, Cincinnati 2, Ohio (July '43) *P*

Wilke, Harvey Robert, 915 N. Salisbury, West Lafayette, Ind. (Jan. '43)

Williams, Fred F., 308 E. 5th St., Fulton, Mo. (Jan. '40) *MP*

Winslow, Edward L., Jr., Knappen, Tippetts, Abbett Co., 62 W. 47th St., New York, N.Y. (Apr. '30)

Yandre, Thomas E., 1901 University Drive, Orlando, Fla. (July '45) *MP*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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C. A.—Chemical Abstracts; I. M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (Great Britain).*

HYDRAULICS

Water Hammer in Pressure Lines With Air Chambers. WILHELM GANDENBERGER. Gas- u. Wasser. (Ger.), **88**:5:146 ('47). Results given of tests measuring pressure rise due to water hammer in ½″ galvanized pipe 330′ long, using several flow veloc., times of closure and amounts of air in air chambers. These results compared with calculated values from formulas by author, some derived from previous publications. Dampening effect of air chamber shown for repetitive pressure wave and increase in air volume. For large air volumes amount of pressure wave is nearly independent of time of closure. Fair correlation exists between experiment and calculation.—*Max Suter.*

Water Hammer Effects in Power Conduits. CHARLES JAEGER. Civ. Eng. (Gt. Br.), **43**:74, 138, 192, 244 (Feb.–May '48). A. W. K. Billing's conclusions, published in Symposium on Water Hammer (A.S.M.E. and A.S.C.E., Chicago, '33) still generally hold good. His hopes of gaining better knowledge of water hammer fulfilled only to limited extent. Analytical and graphical methods developed. Fairly detailed theory of resonance developed. Collection of practical data on design and accidents in operation scanty. Surges may be divided into 4 general types: [1] slow surge, caused by velocity change taking place in time interval longer than period of oscillation and producing pressure fluctuation that diminishes essentially uniformly from maximum at lower end to zero at upper end; [2] rapid surge, caused by velocity change in less than critical time interval, μ, producing pressure fluctuation that is uniform in lower portion and diminishes gradually in upper portion to point of relief; [3] instantaneous surges, caused by very rapid velocity changes in much less than μ, producing pressure fluctuation transmitted with no change to upper portion; [4] rhythmic movements and resonance surges caused by throwing fractional loads on and off, particularly in synchronism with oscillations thus started in penstock. Pressure rises may be much larger than those due to change in loads in timing for which governors are usually specified. Accident occurred at high-head plant built between '06 and '10 and worked without incident until '34 when air inlet valve burst and water, rushing out and flowing down track, damaged pipes. Calculations led to discovery of various possibilities of dangerous negative or positive surges in penstock. Small demands for more water at machines found dangerous in conjunction with low water level in surge tank and even more so if pressures due to water hammer interfered with oscillations of surface level in tank. Another plant has first pressure gallery fed by water under pressure from main stream and second gallery with free flow for taking in tributary. Second gallery, badly designed, acts like siphon and there is continuous flow of air through narrow vertical shaft into surge tank and

(Continued on page 54)

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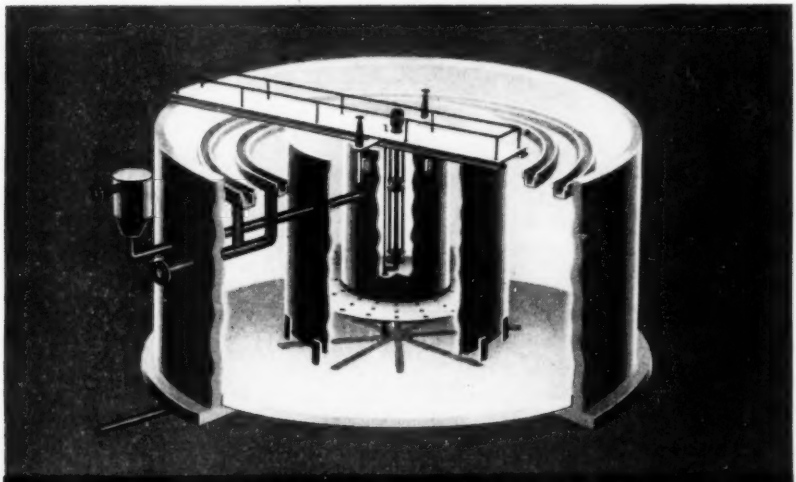

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(*Continued from page 50*)

penstocks. Dangerous vibrations of upper portion of penstock noticed when total load on plant increased. Analogous case has recently come to light. Plant in British colony has been successively enlarged from 1,000 to 3,000 kw. but it has never been possible to utilize full installed power Recalculation showed that bottom of surge tank had been placed too high, causing admission of air to penstock. Remedy was to raise dam, build second surge tank in appropriate position. Failures in older plants instructive for design of new plants. Special importance attached to slopes of pressure gallery and penstock, and to height of surge tank. In many old plants, slopes insufficient or penstocks have dangerous bends leading to negative water hammer surges. Penetration of air into penstocks must be avoided. Most failures or accidents in penstocks, published in technical papers, have been caused by failure or faulty operation of mechanisms. Facts given concerning some other accidents. *Case 4.* Plant with six sets fed by two parallel penstocks 59″ in diam., 400′ long, with head 186′ had distributing pipe of variable diam. at right angles to penstocks at their lower ends. Rock, rolling down mountain, crashed into one penstock at upper end, severely damaging it. Oddly, other penstock was damaged at lower end. Probably violent local impact on first penstock caused strong instantaneous surge. Water hammer wave, traveling downwards, increased because of increasing thickness of pipe walls, and, penetrating at right angles into distributing pipe, again increased due to reflection from closed end. Resonance is dangerous not only for pipeline but sometimes also for tunnel upstream from surge tank. Harmonics can penetrate far into tunnel in spite of presence of surge tank. Trouble generally occurs when flow is low. It can be caused by turbulence of flow, cavitation, or mere hazard. Auto-oscillation most dangerous of all. *Case 9.* Power station equipped with high-powered, vertical-shaft units with high-head Francis turbines working at over 1,000′ head. Vibrations in penstock recorded graphically. Diagram revealed two superimposed phenomena; one due to pulsation resulting from hydrodynamic disturbance within water system supplying turbine; second due to vibration of metallic walls of pipes under sudden changes of pressure. Continuous corresponding pressure changes were revealed in surge tank. By application of formula:

$$y - y_o = \frac{a}{g}(v - v_o)$$

in which $y - y_o$ is change of pressure in phase of water hammer, $v - v_o$ is change of velocity, g is acceleration due to gravity, and a is velocity of propagation of pressure wave in pipeline, it is seen that velocity change of only 0.3 fps. would cause pressure change of as much as 33′. *Case 10.* Well known that movements of some valves can cause serious cavitation and vibration. Now usual to test with models if cavitation is to be expected before designs are adopted. To eliminate cavitation, advisable to introduce air during valve movement. In most systems of pressure conduits, fundamental or higher harmonics can be produced by rhythmically alternating movements of valve. Laws for fundamental seem to differ from higher harmonics. Frequency of fundamental is apparent one, while higher harmonics mostly oscillate in fractions of theoretical frequency. Auto-oscillation occurs if elastic system starts to oscillate together with mass of water in pipe. *Case 11.* At Vobarno, Italy, vibrations along penstock showed frequency of 110 cycles per sec. and max. amplitude exceeding 1

(*Continued on page 56*)

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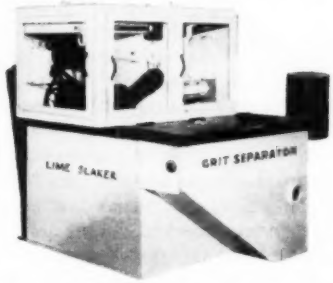

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(*Continued from page 54*)

mm. Analogous cases had been previously observed in U.S. *Case 12.* In nonmodern plant working at heads between 4 and 5 m. continuous speed fluctuations of up to 1% and more were caused by sudden oscillations of load. Fluctuations occurred only when network was supplied by single unit. *Case 13.* Dangerous water hammer can be produced in high-pressure systems containing reciprocating pumps. In system of this kind reflux valve near delivery tank started to vibrate causing springs of flexible coupling between pump and motor to break. Theoretical explanation: given pipeline length of 16.5 m. and wave velocity of 1,000 m./sec. period is 0.066 sec. Flow at speed of 150 rpm. changes periodically in $1/6n/60 = 10/n = 0.066$ sec., exactly same. *Case 15.* At power station at Giais, Italy, so long as turbine is running, penstock is all right. When turbine is shut down by governor, vibrations can be observed. Recording manometer showed that as soon as load exceeded 0.5 max. there was high water hammer pressure. Case has not been satisfactorily explained. *Case 16.* At Lac Noir–Lac Blanc in Vosges, theory of auto-oscillation was put forward to explain catastrophe. At time of accident plant was being tried out and all safety devices had not been installed. Shortly after pumps had been put into operation failure occurred on 15′ distr. pipe. Fractured metal was perfectly sound. Superficial area of hole was 185 sq.ft. Damage was extensive and most of personnel drowned. *Case 18.* Resonance presents serious threat to pressure gallery above surge tank and may even damage it. Theory of resonance shows that surge tank may influence resonance of fundamental of system penstock–surge tank–tunnel in such way that pressure waves penetrating into tunnel will lose considerable force. Theory of harmonics shows that how-

(*Continued on page 58*)

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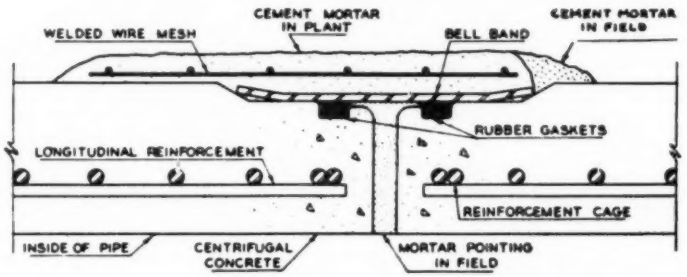

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(*Continued from page 56*)

ever well surge tank is designed harmonics may be transmitted to upstream side. If this deduction applied to pressure system with surge tank it will be found that stationary waves will be propagated into tunnel if and when nodal point of vibration occurs at surge tank. Examples cited are by no means isolated.—*H. E. Babbitt.*

The Hydraulic Investigation of Water Distribution Systems. GORDON M. FAIR. Wtr. & Wtr. Eng. (Gt. Br.), **51**:265 (June '48). If there were no fire demand hydraulic capac. of distribution system would have to equal max. demand for domestic, industrial and other general purposes. Rate at which water should be made available to extinguish fires has been studied in particular by National Board of Fire Underwriters. Central portion of cities with population over 200,000 requires capac. of 12,000 gpm., and from 2,000 to 8,000 gpm. in addition for second fire. For normal drafts, pressure at street line must be at least 20 psi., but 40 psi. is more desirable. Pressure needs at hydrant, according to Freeman: for 100 ft. of hose, 63 psi.; for 600 ft., 135 psi. Hydraulic performance of distribution systems determined most directly and expeditiously by pressure surveys and hydrant tests. In office three methods of analysis will be found particularly useful: [1] method of sections, [2] Hardy Cross method and [3] method of equivalent pipes. Method of sections outlined: cut network by series of lines chosen with due regard to varying sequence of pipe sizes and character of district; estimate water supplied to areas *beyond* each section; estimate capac. of distribution system at each section across piping; on basis of available, or desirable, hydraulic gradient determine capac. of existing pipes and sum them to obtain total capac.; calculate deficiency as difference between required and existing capac.; on basis of available, or desirable, hydraulic gradient select pipes to be added to system in order to offset deficiency; determine size of pipe equivalent to reinforced system and calculate veloc. of flow through system; check important pressure requirements against plan developed for network. In Hardy Cross method systematic corrections applied to initial set of assumed flows until network balanced hydraulically. By method of equivalent pipes, complex system of pipes is replaced by single line of equivalent capac. It cannot be applied directly to system of pipes containing crossovers or takeoffs. Three major components of service storage are: [1] equalizing storage, [2] fire reserve and [3] emergency reserve. Equalizing storage may be ascertained from rate curve or mass diagram. For fire reserve National Board of Fire Underwriters recommends distribution reservoirs be made large enough to supply water for fighting serious conflagration for 10 hr. in communities of more than 2,500 pop., and for 5 hr. in smaller ones. Magnitude of emergency reserve depends on danger of interruption of reservoir inflow by failure of supply works, and on time needed to make repairs. Total storage is equal to sum of component requirements, economic considerations determining final choice.—*H. E. Babbitt.*

Graphical Determination of Pressure Variations in Pipelines. WILHELM GANDENBERGER. Gas- u. Wasser. (Ger.) **89**:3:65 ('48). Long pipelines from pump to reservoir have as rule one or more high points. If pump shut down, reduction in pressure occurs which may pull pressure line below geodetic elevation of high point and thus cause separation of water column. Such separation occurs at negative pressures of 0–28′, depending on amount of air present. Negative

(*Continued on page 60*)

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(*Continued from page 58*)

pressure wave moves through pipeline at velocity a of pressure wave (approx. 3500–4000 fps.). To calculate pressure changes, value of a has to be determined, and velocity of water before shutdown and mode of shutdown must be considered. Time needed for pressure wave to pass between ends and various high points is determined. Negative head at which separation (vacuum) formed has to be known. With these data, course of pressure wave followed graphically, using water hammer gradient determined from $H-H_o=\pm\frac{C_o a}{g}$, where $H-H_o$ is pressure loss, C_o total change in water velocity, a velocity of pressure wave and g acceleration of gravity. If this loss at high point produces vacuum, volume of vacuum can be calculated from sum $\Sigma\ (c-c')\times \frac{d^2\pi}{4}\Delta t$, where $c-c'$ is change in velocity during small time interval, Δt, and d is diam. of pipe. Process of calculation shown in several examples, which demonstrate that each pipeline is special case. Consideration has to be given to pressure wave and its reflexes, and to fact that on separation of water column pressure wave does not pass this vacuum as long as it exists. Some pressure waves may be compensating, others are additive and cause high pressures.—*Max Suter.*

Measuring Gallery Expansion and Elasticity of Rock. W. MULLER. The Engr. (Gt. Br.) **185**:267 (Mar. 12, '48). Tests have proved that internal pressures (in pipes in rock) can be satisfactorily distributed over armor piping, concrete filling and surrounding rock to almost any required degree, provided steel plate is sufficiently flexible and concrete filling forms solid connection between piping and rock. Only hydraulic pressure tests in rock chambers can provide adequate

(*Continued on page 62*)

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(*Continued from page 60*)

information on permeability and strength of rock. Difficulty in expansion tests is to transmit measurements to indicating device situated outside chamber. Simple hydraulic system has given excellent results. In principle, alteration in length which is to be measured is transmitted to spring bellows in cup-shaped measuring device and is thus converted into change in volume. Hardly any inertia. In Rossens test chamber, expansion in vertical direction was greater than in horizontal. Modulus of elasticity was 60,000 kg. per sq.cm. in horizontal, and 40,000 in vertical. Elasticity increases with rising internal pressure owing to increasing humidity of rock. Creep and other processes involving time were observed. Distinct relation between water losses, expansion and elasticity was noted. Water losses rise in almost linear relation to pressure. Concreting can relieve rock only at low pressures. As pressures are increased, concrete cracks in spite of reinforcement and it is not capable of preventing either water losses or expansion to any great extent.—*H. E. Babbitt.*

Characteristics of Solid Granular Particles. MAX HOFSÄSS. Gas- u. Wasser. (Ger.) **89**:5:139 ('48). Relations of bulk volume, solid volume, voids and particle surface discussed as function of particle size. New method for measurement of voids presented based on Boyle-Mariotte's Law, where at constant temperature $pv = K$. After determination of constants of apparatus, sample introduced, its bulk volume determined, and rise in pressure measured after reducing air volume by definite amount. From this, volume of solids and percentage of voids can be determined. Voids so determined include those between particles and those within pores of particles (as in coke). Several examples of measurements given.—*Max Suter.*

The Laws of the Flow of Filtration. JEAN FERRANDON. Génie Civil (Fr.) **125**:24 (Jan. 13, '48). Starting from law of Poiseuille, there is developed tensor nature of physical coefficients on which depend velocity field and field of hydrodynamic action of flow on solid particles of filter. General laws governing these fields established by introducing matrix of permeability and matrix of wetted sections.—*Max Suter.*

EUROPEAN SUPPLIES

The Genissiat Dam—France. ANON. Wtr. & Wtr. Eng. (Br.), **51**: 262 (June '48). France is building Western Europe's biggest dam, second only to Russia's Dnieprostroi, as part of her great Rhone Valley scheme. Genissiat is 12 mi. from Swiss frontier and 43 mi. northeast of Lyons. Turning river into tunnels through banks was done in April '39. Foundation of dam was laid in '40. In June '40 military authorities ordered closing of tunnels and river broke over temporary dam. In May '47 nearly 597,000 cu.yd. of concrete were in place. Width of river 170 ft., thickness of dam at river level 328 ft. Dam is 300 ft. high and at summit has overall width of 460 ft., with thickness of 30 ft. Water face is perpendicular and rear face, after almost vertical drop of 30 ft., slopes sharply down to meet roof of engine-house roughly third of way down. Dam will eventually generate 1.8 bil. kwhr. yearly.—*H. E. Babbitt.*

Industrial Wastes [Fr.]. G. ROUSSE. L'Eau (Fr.) **35**:165, 189 (Oct., Nov. '48). Conception of separate treatment of indus. wastes has not progressed far in France. Each instance requires separate study, but acceptable solutions of problems possible.

(*Continued on page 64*)

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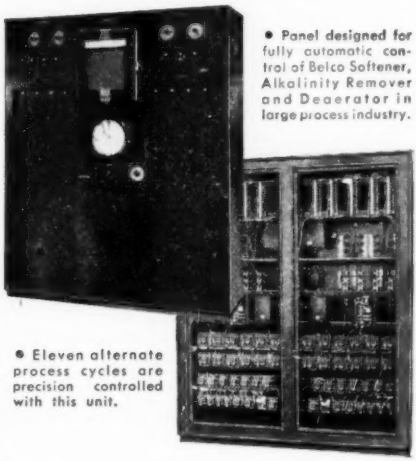

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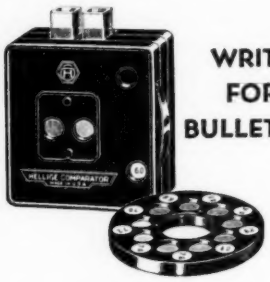

WRITE FOR BULLETINS

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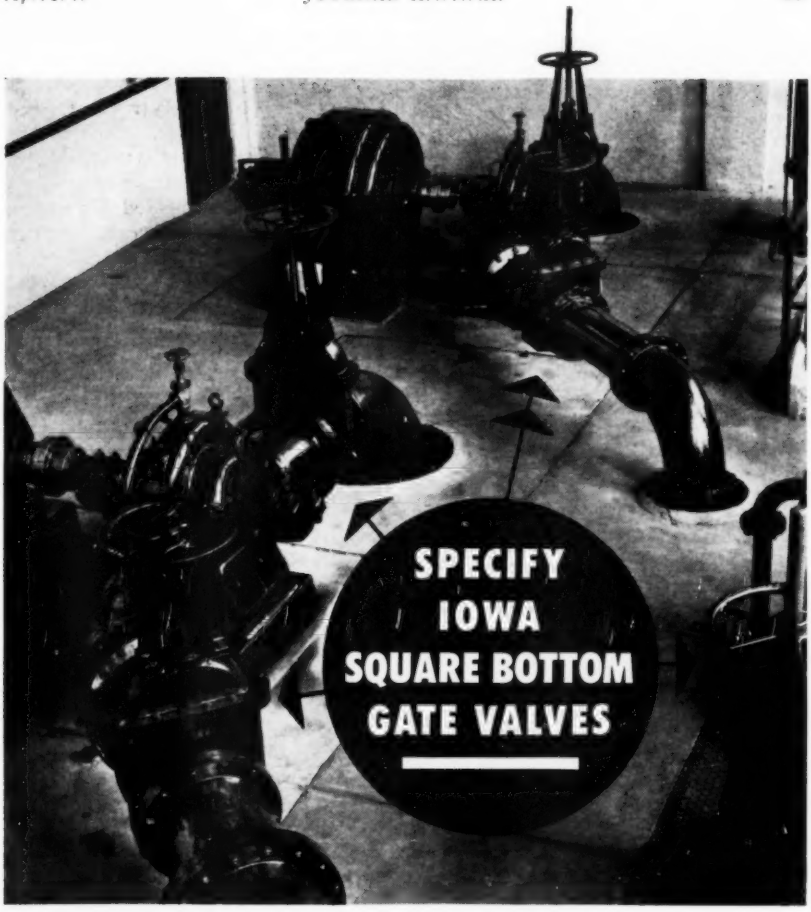
(*Continued from page 62*)

Collaboration of industry with competent administrative agencies needed to alleviate conditions detrimental to public health. Considerable number of san. technicians available, but laws to enforce indus. waste treatment insufficient. Description of modern treatment methods for specific conditions, administrative procedures and possible methods of treatment given. —*W. Rudolfs.*

Operation of Slow Filters [Fr.]. P. BLANCHARD. Tech. Sanit. (Fr.), **43**:54 (May–June '48). Banlieue filters of Paris consist of 109 prefilters covering 25,500 sq.m. and 125 filters covering 72,415 sq.m. Effective size of sand in prefilters varies between 0.6 and 0.7 mm. and uniformity coefficient between 2.7 and 2.8, while effective sand size of filters varies between 0.4 and 0.5 mm., with uniformity coefficient between 2.6 and 2.9. Filtration rate rather constant; backwashing every 7 to 10 hr., using less than 1% of prefiltered water. Raw water has average alkalinity (CaO) of 120 ppm., hardness 22 ppm., pH 7.9, transparency 2, coliform index 300. 80 to 90% of bacteria retained in prefilters. Filtered water of high quality, low in color; coliform organisms absent $\frac{3}{4}$ of year, remainder of year in very small numbers, so that chlorination not needed, but practiced as safety measure.—*W. Rudolfs.*

The Water Distribution at Lille [Fr.]. M. COURTHEOUX. Tech. Sanit. (Fr.), **43**:27 (Mar.–Apr. '48). Potable water available comes to about 52,000 cu.m./day; requirements for 200,000 people, 36,000. Minimum distribution to industry is about 6,000 cu.m. With growth of city, about 60,000 will be required in 1964. Distr. system has insufficient capacity to carry these volumes; question is raised whether to construct separate industrial water system.—*W. Rudolfs.*

(*Continued on page 66*)



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(*Continued from page 64*)

The Val d'Isère Project. A. K. CLARKE. Wtr. & Wtr. Eng. (Gt. Br.), **51**:456 (Oct. '48). Scheme for hydr. installation in Savoy Alps involves constr. of gigantic reservoir in gorge of Isère, to be fed by natural drainage and by network of ducts some 200 mi. long draining French, Swiss and Italian Alps. Reservoir will operate 2 subterranean generating stations in France, one in Switzerland and 2 in Italy. Four main branches of collecting system are: [1] northern, originating in Switzerland, beneath Diablerets; [2] eastern, draining Alps de Graies, [3] western, draining Massif of Vanoise and [4] southwestern, draining Massif de Pelvoux. Northern branch of special interest. During spring and summer waters led into reservoir by collecting system, sufficient water being available to drive both Swiss and Italian stations and also replenish reservoir. During winter flow will be outward from reservoir to generating stations. Main biflow artery will have const. diam. of nearly 42'. Total cost of constr. estd. at 380 bil. French francs.—*H. E. Babbitt.*

The Ground Water Supply at Dordrecht [Neth.]. A. F. MEIJER. Water (Neth.), **32**:119, 129, 139, 149, (June 21, July 8, July 22, Aug. 5, '48). Historical development over 40 years; water obtained from series of wells required softening and iron and manganese removal. New treatment plant construction begun in 1942 consisting of aeration, softening with lime, rapid sand filters and settling. Cost of entire installation, including pumps and storage tank, 1,124,000 guilders.—*W. Rudolfs.*

The Water Supply for Amsterdam—Pollution and Self-purification of the River Vecht. J. KOOŸMANS. Water (Neth.), **32**:169 (Sept. 2, '48). Vecht R. directly connected with mainte-

(*Continued on page 68*)

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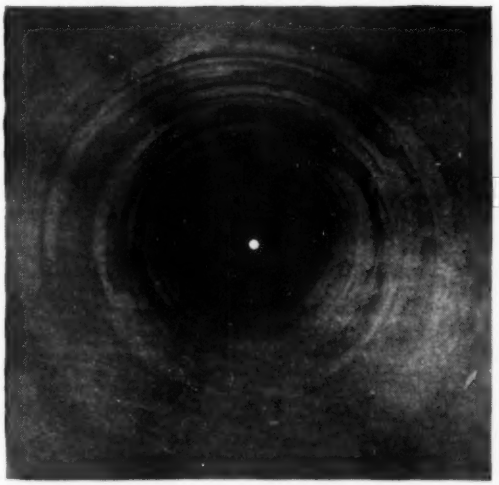

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(*Continued from page 66*)

nance of water levels in Loosdrecht natural lakes which supply part of water for Amsterdam. Considerable pollution of river and rather high color. Self-purification of river 1940–47 is indicated by average reduction of total NH_3 from 6.0 to 4.6, B.O.D. from 22 to 12 ppm., 20°C. bacteria count from 2,280,000 per ml. to 640,000, 37°C. count from 143,000 to about 20,000 per ml., M.P.N. coli from 700 to 50 per ml. Average results do not indicate degree of pollution, which is substantially higher during winter months when self-purification retarded.—*W. Rudolfs.*

Organic Matter in Some Waters in Moscow Vicinity. B. A. SKOPINTSEV. Doklady Akad. Nauk S.S.S.R. (U.S.S.R.), **61**:293 ('48). Report on 10 samples of waters from several rivers of area. Data given on color, hardness, alky., org. matter, C, N, P and B.O.D. Pointed out that for org. matter in waters, factor of 2 instead of 1.72 should be used, since C content usually closer to 50%.—*C.A.*

HEALTH AND HYGIENE

Lactobacillus acidophilus Counts in the Saliva of Children Drinking Artificially Fluorinated and Fluorine-free Communal Waters. S. B. FINN & D. B. AST. Science, p. 292 (Sept. 26, '47). Direct correlation between number of *Lactobacillus acidophilus* organisms in saliva and dental caries activity in mouth. Where there is active dental decay, number of those organisms usually not less than 20,000 /ml. of saliva, while in mouths showing apparent immunity to caries, number of those organisms may not exceed 100/ml. In Newburgh, N. Y., sodium fluoride has been added to water supply since May '45 to give fluorine content of 1 ppm. Shortly before this addn. was made, samples of saliva were collected from 244 children of school age, and it was found that 63.5% of them had *Lactobacillus* counts of 20,000 or over, while 11.9% had counts of less than 100. Early in '47, samples of saliva from 421 children were examd. and only 47.3% had high *Lactobacillus* counts while 20% had counts of less than 100. In Kingston, which is nearby comparable town, except for fact that water is fluorine-free, similar tests carried out in '46 and '47 showed about 54% with high counts and 16% with low counts. —*B.H.*

Thyroid Enlargement and Other Changes Related to the Mineral Content of Drinking Water (With a Note on Goiter Prophylaxis). MARGARET M. MURRAY ET AL. Med. Res. Council Memorandum (Gt. Br.), No.

(*Continued on page 70*)

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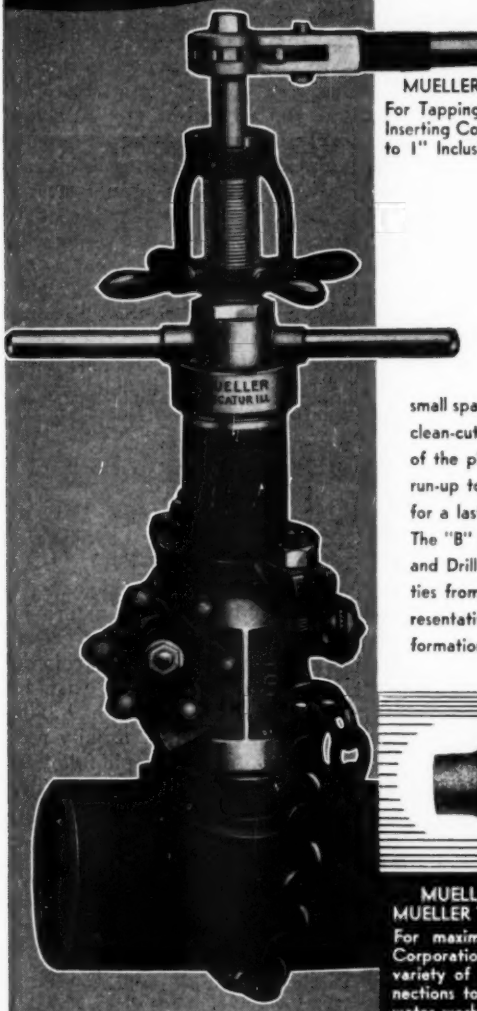

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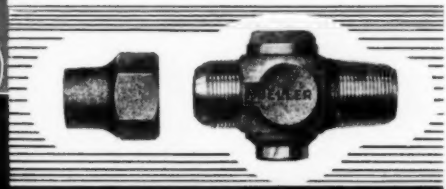

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(*Continued from page 68*)

18 ('48). Clinical assessment of thyroid enlargement forms Part I of this report on endemic goiter. Part II deals with endemic goiter in Great Britain in relation to iodine, calcium and fluorine content of water supply. Scientific literature from 1800 to 1924 has recorded endemic goiter in some 30 English counties and in certain regions of Wales; particularly high incidence in Derbyshire, Gloucestershire, Nottinghamshire and Somersetshire. Since '24 these findings have been confirmed and extended. Authors have added Devonshire, Dorsetshire and Oxfordshire to list of counties with high incidence. Records for Scotland and Ireland are scanty, but evidence of goiter in 15 Scottish counties, all counties of Northern Ireland and 6 counties of Eire. Report discusses association of thyroid enlargement and iodine content of water supply and sets forth data obtained by authors in surveys of school children, adult women and village pop. Iodine content of 145 samples of drinking water in England and Scotland detd. Results obtained bear out general hypothesis that there is relation between incidence of thyroid enlargement and iodine level in water although this relation is not as clearcut as in American surveys. Higher incidence of goiter and thyroid enlargement in certain areas of England, as compared with that in certain Scottish areas having waters of similar iodine content, might be attributed to degree of hardness of these English waters in contrast to softness of Scottish waters. Not possible to investigate relation of endemic goiter to endemic fluorosis, because so few waters in England with sufficiently high fluorine content. Fresh evidence submitted showing association of endemic cretinism and congenital deaf-mutism with high incidence of goiter. Prophylaxis against thryoid enlargement and goiter by general use of iodized salt desirable in Great Britain. Recommended that 1 part of potassium iodide be added to every 100,000 parts of all salt or 1 part to 40,000 parts of packaged table salt.—*B.H.*

CHEMICAL ANALYSIS

Determination of Iron in Colored Waters. L. I. BEZEL. Zavodskaya Lab. (U.S.S.R.), **14**:799 ('48). Usually detn. of Fe by thiocyanate method in cold gives low values in comparison with hot titration. Difference is greater when natural, colored waters analyzed, in which Fe exists in form of complex salts with humic acids. In order to elim. usually recommended evapn. of sample followed by H_2O_2 treatment, NH_4 persulfate

(*Continued on page 72*)

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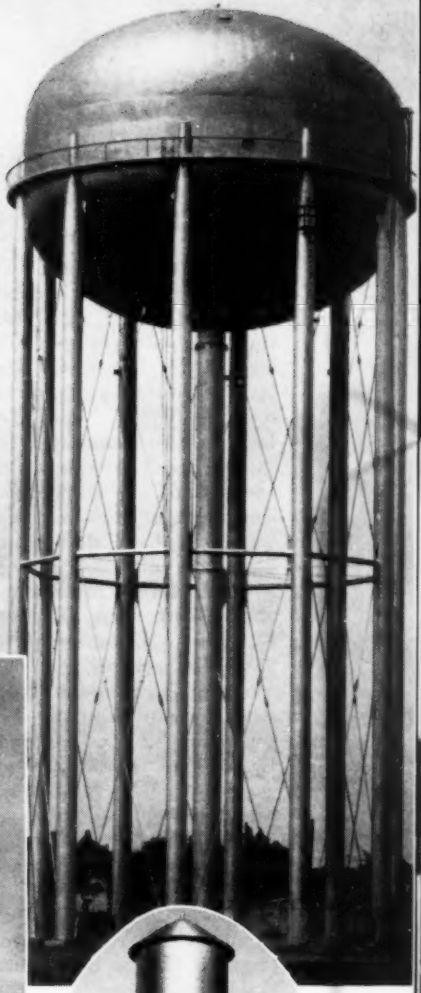

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(*Continued from page 70*)

and $KMnO_4$ methods studied. Found that use of any of oxidizing agents without prelim. destruction of hu mates by heating (baking) still gives low results. Following procedure recommended: water sample acidified by HCl, treated with H_2O_2 in cold, then Fe pptd. by NH_4OH, filtered, washed by hot water, dissolved in HCl, and detd. by thiocyanate method colorimetrically. This gives "ionic" Fe. Total Fe obtained after baking sample to destroy humates. Difference is amt. of "complex" Fe. Typical anals. of various river and mine waters cited.—*C.A.*

A Field Method for Water Investigation With Ion Exchangers. M. BLUMER. Experientia (Swiss), **4**: 351 ('48). Rapid method described for detn. of cations in natural waters. After measurement of pH and titration for alky., cations exchanged for H ions in resin-exchange column. Titration with NaOH shows total cation content, with error not exceeding 1%. Free CO_2 and permanent and temporary hardness can be estd. from 3 values.—*C.A.*

Products of Acidic Hydrolysis of Organic Matter of Natural Waters. B. A. SKOPINTSEV. Doklady Akad. Nauk S.S.S.R. (U.S.S.R.), **62**:243 ('48). Natural waters collected from several rivers in vicinity of Moscow, as well as from minor lakes and swamps, especially after storage in dark, contain materials which on acidic treatment give pos. furfural test. Amt. of furfural, so found, ranges from few to over 100 γ/l. in river or lake waters, and up to 600 γ/l. in swamp waters, especially after addn. of phytoplankton. Procedure was to conc. sample to 70 ml., add HCl to give 12% acid concn., boil with distn. of 30 ml., add HCl (30 ml. 12%), and dist. off 30 ml.; distillate (5 ml.) treated with 0.5 ml. $PhNH_2$, 4 ml. AcOH and enough water to make 10 ml.; after 15 min., soln. measured colorimetrically. If waters from river sources or from Moscow water reservoirs pretreated with phytoplankton kept in dark 1–3 mo. with shaking and treated as above, after filtration, color not pink but yellow; this indicates methylfurfural, i.e., methylpentosan content of original waters. Disappearance of pentosans (and related substances) and their replacement by methylpentosans connected with decompn. of dead phytoplankton and not observed in winter lake waters or in summer swamp waters, which on acid hydrolysis give furfural. Eleven references given to literature on org. content of natural waters after hydrolytic treatment. —*C.A.*

(*Continued on page 74*)

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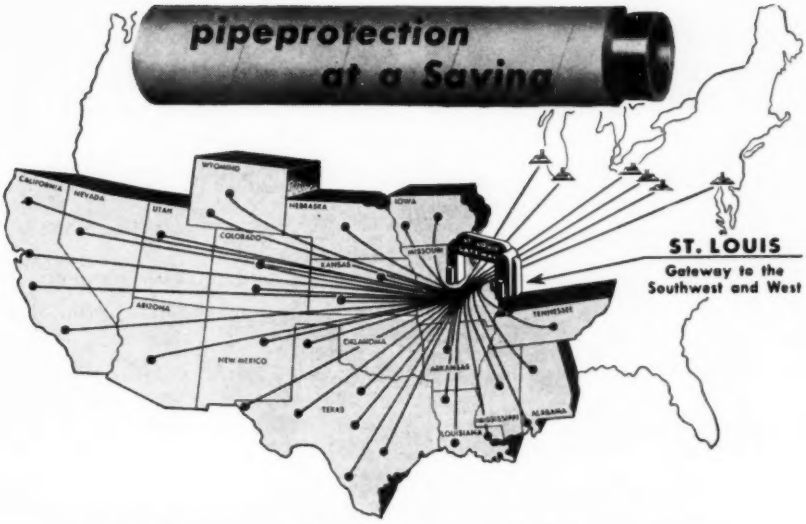

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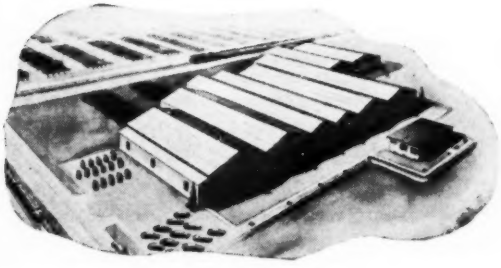

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500 Fifth Ave., New York 18, N.Y.

(Continued from page 72)

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals not abstracted, are listed below.

Public Water Supplies for Fire Fighting. JOHN WEST. Nat. Fire Protect. Assn. Quart. **42**:3:199 (Jan. '49).

Delaware Aqueduct to Increase New York's Water Supply Fifty Per Cent. ROGER W. ARMSTRONG. Civ. Eng., **19**:2:17 (Feb. '49).

The Need, Design and Construction of the Liberty Road—Montebello Water Tunnel. BERNARD L. WERNER. Proc. Md.–Del. Wtr. & Sew. Assn., p. 57 (Apr. '48).

The Ortho-Tolidine-Arsenite Test in Water Chlorination. HARRY A. FABER. Proc. Md.–Del. Wtr. & Sew. Assn., p. 5 (Apr. '48).

History of Toxic Plankton and Associated Phenomena. THEODORE A. OLSON. Sew. Wks. Eng., **20**:2:71 (Feb. '49).

An Effective Joint Seal for Reinforced Concrete Tanks. R. C. KENNEDY. W.W. Eng., **102**:2:131 (Feb. '49).

The Effect of Soil Moisture on Buried Receivers for Heat Pumps. W. A. HADLEY. Edison Elec. Inst. Bul., **17**:1:12 (Jan. '49).

Latest Developments in Soil Solidification. C. M. RIEDEL. Midwest Engr., **1**:6:6 (Feb. 15, '49).

Maryland Program for Water Pollution Control. PAUL W. MCKEE. Proc. Md.–Del. Wtr. & Sew. Assn., p. 11 (Apr. '48).

Recreational Use of Watersheds of Public Water Supplies. C. A. HECHMER. Proc. Md.–Del. Wtr. & Sew. Assn., p. 16 (Apr. '48).

Litigation Affecting Water Rights, Easements, etc. LEO T. PARKER. W.W. Eng., **102**:2:123 (Feb. '49).

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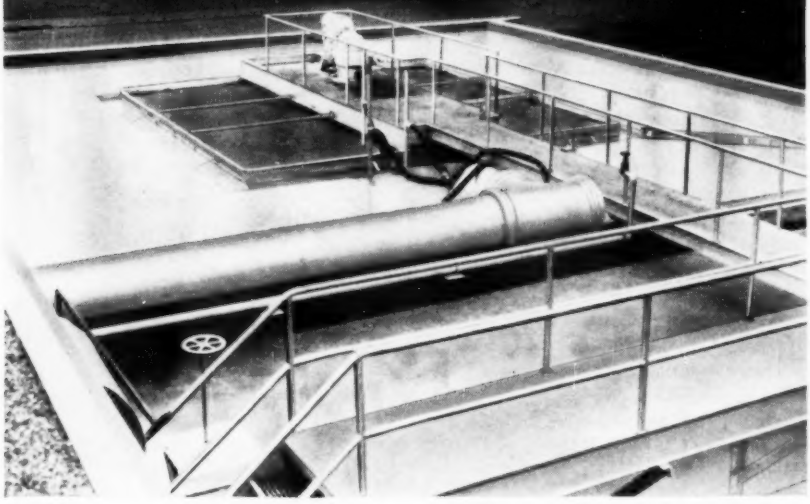

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Service Lines

"Valves and Gates for Hydraulic Equipment" are described in an 8-page bulletin available from Westinghouse Electric Corp., Box 868, Pittsburgh 30, Pa. Among the products of the company's newly acquired Sunnyvale Plant are butterfly valves, slide and sluice gates, cylinder gates, hollow jet free discharge valves, and other large items of equipment for the control of hydraulic projects.

A coil-spring vacuum filter for dewatering sludge is described in a brochure available from Engineering Sales Corp., 43 Leon St., Boston 15. Produced by the Komline-Sanderson Engineering Corp. of Ridgewood, N. J., the filter is said to give constant output with minimum difficulty because the filter medium never clogs. Consisting of two sets of coiled springs laid in corduroy fashion and traveling on rollers, the springs separate at one stage of the cycle for washing, then come together again for filtration. A completely clean medium is thus presented at all times.

Nozzles for washing and cleaning operations are the subject of a new Chain Belt Co. bulletin, No. 48-38. Entitled "Rex Flat Spray Nozzles," the booklet offers descriptions, illustrations and operating data for the nozzles. Available from the company, at 1600 W. Bruce St., Milwaukee 4, Wis.

Smith-Blair, Inc., has issued a new general catalog describing its repair and service clamps, and various types of couplings. A section entitled "How to make your own repair clamps" is included. The company can be addressed at Box 66, South San Francisco, Calif.

Clarifiers for water and sewage treatment produced by Infilco, Inc., 325 W. 25th Place, Chicago 16, are described in a 16-page bulletin recently made available. Entitled "Quiescent Clarification," the bulletin is illustrated by diagrams and photographs and explains the action of an automatic hydraulic skimmer.

"Waste Treatment to Comply With Stream Pollution Control Regulations" is the title of another Infilco, Inc., booklet. Intended for the information of the industrial plant executive or municipal engineer, the bulletin discusses the general problems involved and reports actual case studies.

(*Continued on page 78*)

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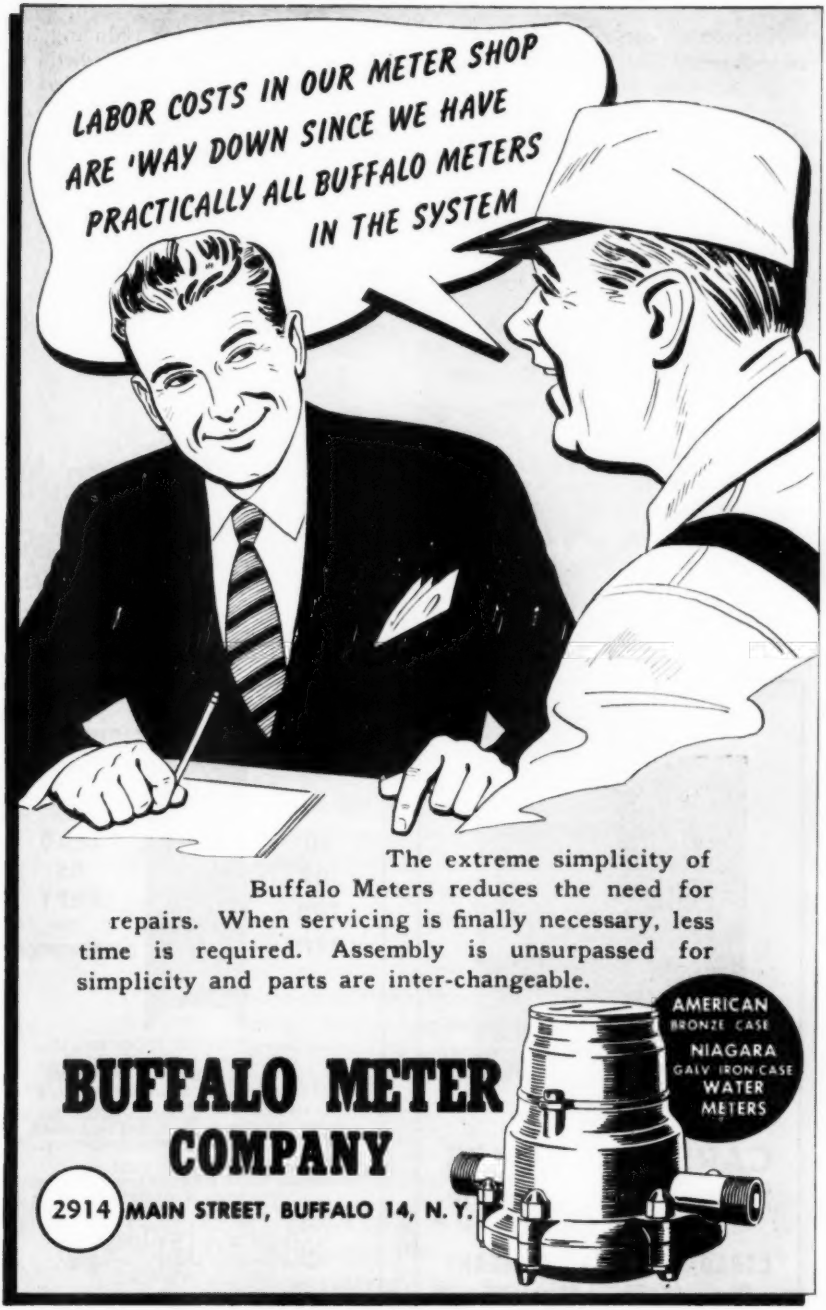

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NIAGARA GALV. IRON CASE
WATER METERS

(Continued from page 76)

Horizontal centrifugal pumps in an augmented line, designated Peerless Type A, have been announced and described in a 20-page bulletin, No. B-1300, published by Peerless Pump Div., Food Machinery & Chemical Corp., Los Angeles 31, Calif. The pumps are of single-stage, double-suction, split-case design and come in sizes from 1¼ through 48 in.

A lever-operated portable tool, small and light enough to stow in tool boxes but capable of lifting or pulling 1- or 2-ton loads, is described in Bul. 388 of Manning, Maxwell & Moore, Inc., Muskegon, Mich. Known as the "Tugit," the hoist comes in models that give a lift of 5 to 12 ft. upon the application of 40 lb. of pull on the 12-in. handle.

Oily waste cans for reducing fire hazards are described in a bulletin of the Protectoseal Co., 1920 S. Western Ave., Chicago 8, Ill., entitled "New Protectoseal Safety Products." Safety containers for liquids and various cans and tanks for other applications are included.

Electrophotometer use and operating features are the subject of a booklet issued by Fisher Scientific Co. and Eimer & Amend. The simplicity of colorimetric analysis techniques is stressed.

Pipe repair clamps produced by Stauffer Mfg. Co. are described in a four-page folder entitled "Stop That Leak!" Tables of dimensions and prices are included. Available from the company at 8424 Otis St., South Gate, Calif.

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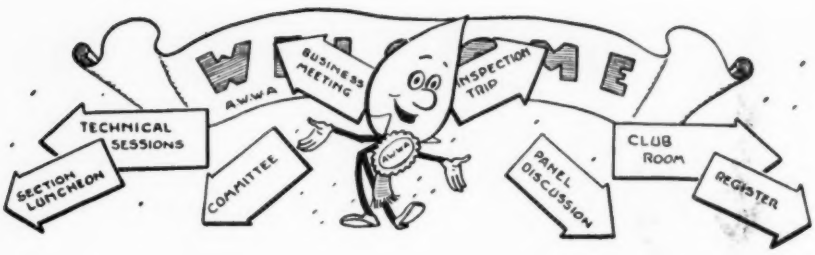

Section Meeting Reports

New York Section: The Annual Mid-Winter Luncheon of the New York Section was held jointly with the American Society of Civil Engineers (Sanitary Engineering Division) and the New York State Sewage Works Association in the Grand Ballroom of the Hotel Statler, New York, on Friday, January 21, 1949. Many of the visiting civil engineers attending the annual A.S.C.E. meeting in New York were present.

The guest speaker at the luncheon was Harold C. Ostertag, Chairman of New York's Joint Legislative Committee on Interstate Cooperation, who spoke on "Pollution Control Legislation in New York State." The Section recommended and voted favorably on urging legislation for pollution control in the current bill which is before the legislature.

Maj. Gen. Philip B. Fleming, Administrator, Federal Works Agency, Washington, D.C., ably presented a paper on "The Federal Works Agency and Water Pollution Control." Following this, a paper was presented on "The 26th Ward Sewage Treatment Works, Brooklyn, N.Y.," by S. W. Steffensen, Project Manager and Deputy Chief, Bureau of Sewage Disposal Design, Department of Public Works of New York City.

A Social Hour was held in the Manhattan Room from 5:00 to 6:00 P.M. through the courtesy of the Water and Sewage Works Manufacturers Association.

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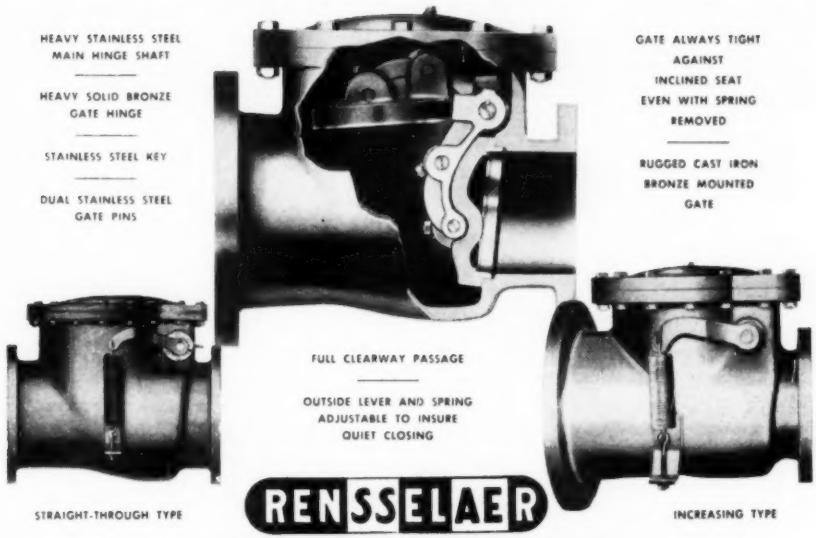
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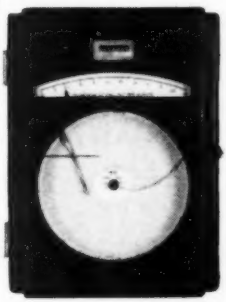

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A. P. Smith Mfg. Co.
Rensselaer Valve Co.
Ross Valve Mfg. Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
Hellige, Inc.
LaMotte Chemical Products Co.
Wallace & Tiernan Co., Inc.

Iron Removal Plants:
American Well Works
Belco Industrial Equipment Div., Inc.
Chain Belt Co.
Infilco, Inc.
Liquid Conditioning Corp.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Jointing Materials:
Atlas Mineral Products Co.
Michael Hayman & Co., Inc.
Hydraulic Development Corp.
Leadite Co., Inc.
Northrop & Co., Inc.

Joints, Mechanical, Pipe:
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Dresser Mfg. Div.
Smith-Blair, Inc.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Lime Slakers and Feeders:
Dorr Co.
Infilco, Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)

Manometers, Rate of Flow:
Builders-Providence, Inc.

Meter Boxes:
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.
Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
James Jones Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Smith-Blair, Inc.
Worthington-Gamon Meter Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.
Buffalo Meter Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meter Washers:
Mabbs Hydraulic Packing Co.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
A. P. Smith Mfg. Co.
R. W. Sparling
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Belco Industrial Equipment Div., Inc.
Chain Belt Co.
Infilco, Inc.

Ozonation Equipment:
Welsbach Corp., Ozone Processes Div.

Packing, Rawhide:
Mabbs Hydraulic Packing Co.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Preload Companies, The
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Dearborn Chemical Co.
Koppers Co., Inc.
Preload Companies, The
Reilly Tar & Chemical Co.
Standard Pipeprotection, Inc.
Warren Foundry & Pipe Corp.

Pipe, Concrete:
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials:
(See Jointing Materials)

Pipe, Steel:
Armco Drainage & Metal Products, Inc.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Smith-Blair, Inc.
Warren Foundry & Pipe Corp.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Centrifugal:
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Chemical Feed:
Everson Mfg. Corp.
Infilco, Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc

Pumps, Deep Well:
American Well Works
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Pumps, Diaphragm:
Dorr Co.
Proportioneers, Inc.

Pumps, Hydrant:
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Fairbanks, Morse & Co.
Ross Valve Mfg. Co.

Pumps, Sewage:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

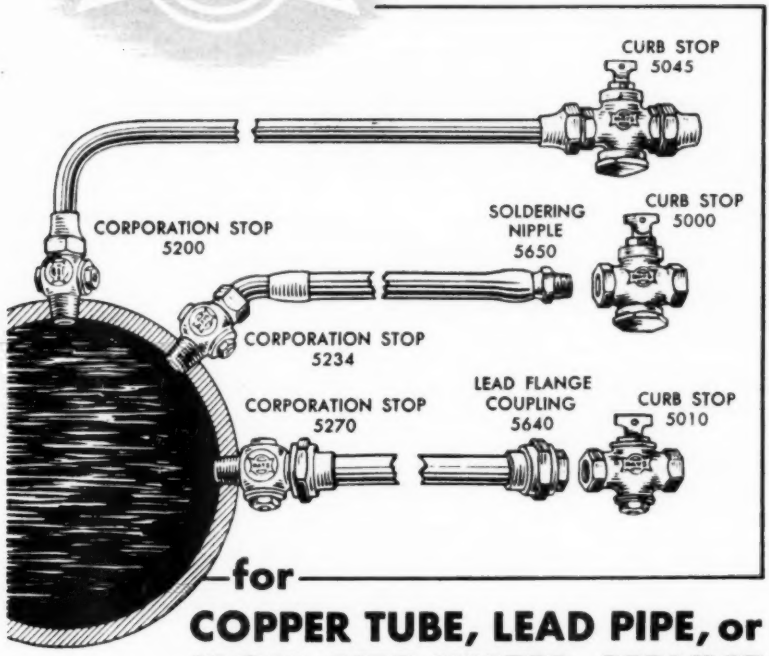
Pumps, Sump:
DeLaval Steam Turbine Co
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Recorders, Gas Density CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.

Recording Instruments:
Builders-Providence, Inc.
Infilco, Inc.
R. W. Sparling
Wallace & Tiernan Co., Inc.

HAYS CORPORATION and CURB STOPS



for COPPER TUBE, LEAD PIPE, or IRON PIPE WATER SERVICE

HAYS water service products are installed in all parts of the world. The Hays Manufacturing Company is one of the largest in its field, and high quality has been maintained throughout the eighty years of its life.

Only the highest quality water works bronze (85-5-5-5) is used. Every fitting is precision machined and hydrostatically tested at 200 pounds or more. All curb and corporation stops are specially lubricated for easy and enduring operation.

HAYS corporation stops can be installed with any standard tapping machine equipment and all water works fittings are interchangeable with other makes.

Ask for our new complete catalog of water service products.

HAYS COPPER · BRASS · LEAD · IRON
WATER WORKS PRODUCTS
HAYS MANUFACTURING CO., ERIE, PA.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Rust Prevention:
Dearborn Chemical Co.
Electro Rust-Proofing Corp.

Sand Expansion Gages:
(See Gages)

Sand, Filtration:
(See Filtration Sand)

Sleeves:
(See Clamps)

Sleeves and Valves, Tapping:
James B. Clow & Sons
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Liquid Conditioning Corp.
Permutit Co.

Soda Ash:
Mathieson Chemical Corp.
Solvay Sales Div.

Sodium Hexametaphosphate:
Calgon, Inc.

Softeners:
Belco Industrial Equipment Div., Inc.
Dearborn Chemical Co.
Dorr Co.
Infilco, Inc.
Liquid Conditioning Corp.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Infilco, Inc.
Liquid Conditioning Corp.
Permutit Co.
Tennessee Corp.
Zeolite Chemical Co.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Storage Tanks:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Strainers, Suction:
M. Greenberg's Sons
R. D. Wood Co.

Sulfur Dioxide, Liquid:
Virginia Smelting Co.

Surface Wash Equipment:
Liquid Conditioning Corp.
Permutit Co.
Stuart Corp.

Swimming Pool Sterilization:
Belco Industrial Equipment Div., Inc.
Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Taste and Odor Removal:
Industrial Chemical Sales Div.
Infilco, Inc.
Liquid Conditioning Corp.
Proportioneers, Inc.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Telemeters, Level, Pump Control, Rate of Flow, Gate Position, etc.:
Builders-Providence, Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
Central Foundry Co.
James B. Clow & Sons
Ford Meter Box Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
James B. Clow & Sons
M. Greenberg's Sons
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
M. Greenberg's Sons
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Vibrators (Chemical Feeding):
Syntron Co.

Waterproofing
Dearborn Chemical Co.
Inertol Co., Inc.

Water Softening Plants:
(See Softeners)

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
LaMotte Chemical Products Co.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dearborn Chemical Co.
Dorr Co.
Everson Mfg. Corp.
Infilco, Inc.
Liquid Conditioning Corp.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Stuart Corp.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Well Acidizing:
Dowell Incorporated

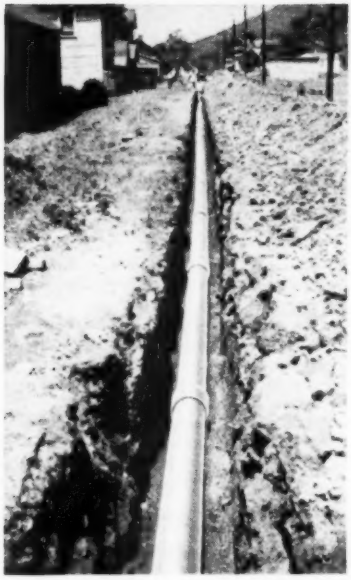
Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite:
Infilco, Inc.
Liquid Conditioning Corp.
Permutit Co.
Roberts Filter Mfg. Co.
Zeolite Chemical Co.

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1948 Membership Directory.

Fast, easy, low cost installation...plus a long, trouble-free life...



Typical installation of K & M "Century" Asbestos-Cement Pipe, laid in western Pennsylvania.

K & M "Century" ASBESTOS-CEMENT PIPE

You gain all along the line when you choose "Century" Asbestos-Cement Pipe for your underground water mains . . . in long distance conveyance, distribution through city streets or for force mains on sanitary sewers.

Work goes fast, for "Century" Pipe is easy to install . . . can be cut, drilled and tapped on the job. And its light weight requires fewer men to handle . . . a factor which also means lower freight, trucking and handling costs.

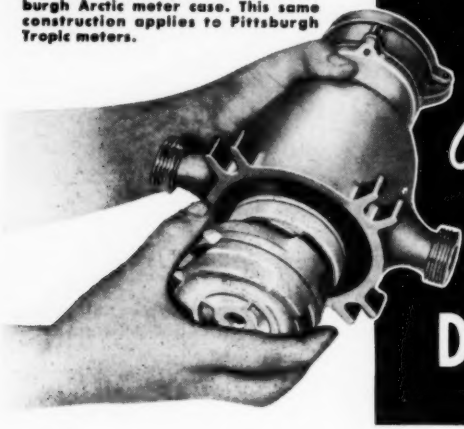
Once laid, you can count on extra years of maintenance-free service, for "Century" Pipe is immune to corrosion, electrolysis, tuberculation. The flexible couplings minimize the effects of traffic vibration and earth settlement. Being made of asbestos and cement, it actually grows tougher with age. In fact, so free is "Century" Pipe from the common enemies of pipe lines, it can be removed after years of service and reinstalled for further use at original pressure.

Learn the many interesting facts about this truly superior pipe. Your inquiry will receive prompt attention.

K&M best in asbestos

Nature made Asbestos . . . Keasbey & Mattison has made it serve mankind since 1873.

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA



Illustrating how working assembly is placed as a complete unit in Pittsburgh Arctic meter case. This same construction applies to Pittsburgh Tropic meters.

HOW YOU BENEFIT FROM *UNIT CONSTRUCTION* IN PITTSBURGH DISC METERS

OUTWARDLY all water meters look practically alike. And the "innards" of most disc meter designs follow a familiar pattern. But there's one all-important difference in the Pittsburgh line. It's the *unit assembly of working parts.*

Here is why this construction is better. Since the measuring chamber, disc and intermediate train all assemble as a complete unit, they can be tested as such for alignment and free running qualities *before* being bolted into the meter housing. This design is justly popular with meter maintenance men whose work it simplifies.

Further, since no part of this unit assembly is attached to the meter case, should freezing occur, the entire working mechanism is free to move downward when the bottom casting breaks, thus preventing possible damage.

Want more facts about benefits of investing in accurate, long-lived Pittsburgh disc meters? Write for bulletins.

PITTSBURGH EQUITABLE METER DIVISION

Rockwell Manufacturing Company • Pittsburgh 8, Pa.

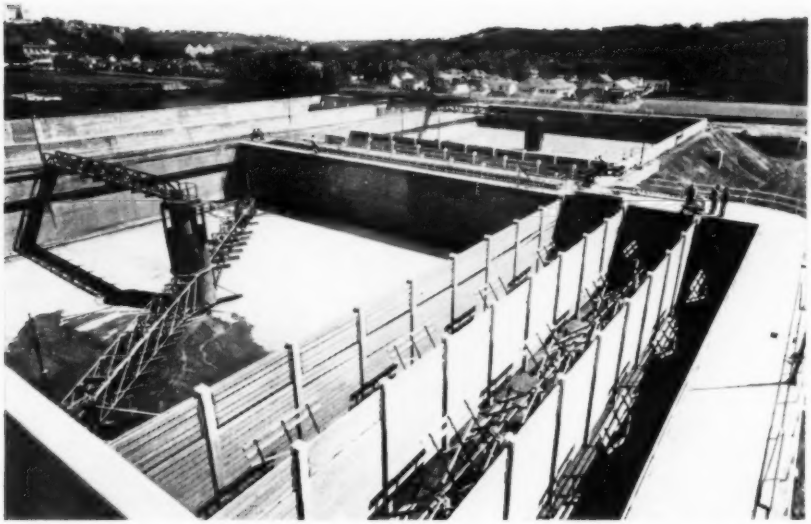
Atlanta Boston Chicago Houston Kansas City Los Angeles
New York Pittsburgh San Francisco Seattle Tulsa

ARCTIC TYPE
A BRONZE METER WITH BREAKABLE FROST BOTTOM

Circular or straight reading registers are optional

TROPIC TYPE
ALL-BRONZE, SPLIT CASE CONSTRUCTION

THE DORRCO FLOCCULATOR AND THE DORRCO SQUAREX CLARIFIER + **STANDARD CHEMICALS** = **REAL SAVINGS FOR YOUR WATER TREATMENT PROJECT**



One of the primary advantages resulting from the use of the Dorrco Flocculator and Dorrco Squarex Clarifier in combination is that standard chemicals, such as alum and lime, may be used exclusively. In many cases, this results in a marked saving in operating costs as opposed to other types of water treatment units where expensive flocculating agents and close operating control are required. In numerous installations, Dorrco Flocculators have paid for themselves in a very few years by savings in chemicals and improved overall plant operation.

Also unique with the Dorrco Flocculator and Dorrco Squarex Clarifier is the substantial saving in first cost due to the inexpensive commonwall construction. The entire unit is cast in a single structure permitting a minimum of pipe lines and channels . . . and having a compact, attractive layout. Where multiple units are required, as in the above view of a recent Dorr installation, the tank shape is ideal.

$ Let an experienced Dorr engineer show you how the Dorrco Flocculator-Squarex Clarifier team will go to work for you on a dollar-saving basis.

DORRCO

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570 LEXINGTON AVE., NEW YORK 22, N. Y.
ATLANTA • TORONTO • CHICAGO
DENVER • LOS ANGELES
RESEARCH AND TESTING LABORATORIES
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SUGAR PROCESSING
PETREE & DORR DIVISION, NEW YORK 22, N. Y.
ASSOCIATES AND REPRESENTATIVES
Dorr Technical Services and Equipment Are Also Available Through Associated Companies and Representatives in the Principal Cities of the World. Names and Addresses on Request.

DORR

RESEARCH — ENGINEERING — EQUIPMENT

LEADITE

Trade Mark Registered U.S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking